A multi-level framework approach to improve organisational business process understanding within automotive manufacturing

A thesis submitted for the degree of

Doctor of Philosophy

by

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Abstract

Business processes are an integral part of today's multinational corporations, allowing them to create best practice working models. Not only do business processes play an important role in defining working practices, they can also provide a basis for understanding and improvement. One key difficulty is to capture multiple aspects of a process. Capturing these allows an organisation to use these models for multiple purposes, such as learning while obtaining a high process maturity. There is not a single modelling technique that spans over multiple purposes.

This research provides a critical overview of the literature of business process modelling to propose a multi-level framework (MLF). This framework aims to model a single cross-functional process using multiple modelling techniques to address different organisational purposes and achieve a higher process maturity. Three modelling techniques were identified as appropriate to form part of such a framework: Rich Picture Diagrams (RPD), Business Process Modelling Notation (BPMN) and 4D ontologies. Design Science Research was used in three iterations to build the levels of the multi-level framework in an iterative and incremental design approach. The first two iterations used semi-structured interviews to gather data, involve stakeholders and evaluate the models, whilst the third iteration proposes a method to develop and evaluate 4D ontologies.

The created artefacts form the process overview (using RPD), application view (using BPMN) and semantic view (4D) levels for the final MLF of a cross-functional process. It addresses organisational purposes such as learning, process development and IT requirements, and covers maturity levels from process creation to optimisation. Involvement of stakeholders in the development and evaluation revealed high satisfaction with the provided views and increased their understanding of the process. Future work would further evaluate the overall framework and study the effects of full implementation within industry.

Acknowledgements

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Chapter 1. Introduction

1.1. Research background

1.1.1. Business processes in a world of multinational corporations

Processes have played important roles as early as during the industrial revolution. Initially dividing production systems into tasks allowed for an increase in productivity and quality (Smith, 1776; Becker and Murphy, 1992; DaSilva and Trkman, 2014; O'donnell, 2016). The application and use of manufacturing processes became more widely spread after the 2nd World War, with such initiatives such as the Toyota production system focusing on minimising waste and improving quality within the vehicle production environment (Krafcik, 1988; Liker, 2003; Spear and Bowen, 2006). With the rise of the Multinational corporation (MNC), research started focusing on business processes, their definition, improvement and redesign. By then the "modern" business process was more complex, its segmentation spanning over multiple countries, companies, departments (Hammer, 1990; Root, 1994).

MNCs have complex process that span over multiple countries that promote "best practice" working and its documentation using business process (Smelser and Baltes, 2001), allowing them increase productivity and remain cost effective, whilst maintaining their quality standards. Business process are well established with today's industry and the business process models used to capture workflow to improve organisation understating, quality and lowering cost (DaSilva and Trkman, 2014).

1.1.2. Business process models

The ability to capture and document business processes allowed for improvements or in sometimes more radical re-engineering of the process (Davenport, 1993, 2010; Hammer and Champy, 1993; Hammer, 2010). It is common for process to be initially defined however after not being used they actually deviate from actual working practice (Van Nuffel and De Backer, 2012). Engaging the organisation is therefore critical not only to capture organisational knowledge pertaining to processes (Bitkowska, 2017) but also to ensure their BPM are used and upkept; this avoids misunderstanding processes which could lead to incorrect execution and preventing improvement (Hammer, 2010). There are a multitude of different approaches and techniques for modelling processes with each solving a different purpose (Aguilar-Savén, 2004), such as

- organisational learning,
- process development,
- process simulation
- and execution and finally IT requirements.

Apart from understanding the purpose of a particular model, an understanding what level of process maturity you are trying to address is also required (Process: creation, repeatable, defined, management, optimisation). Therefore, the same organisation might require different modelling techniques for their processes (rather than relying on one method), including multiple models of the same process.

Business Process Maturity Models (BPMM) such as Capability Maturity Model Integration (CMMI) offered a structured approach for increasing the organisation's capability to perform processes. Different maturity levels of business process exist: ranging from having no apparent structure in place and producing uncontrolled and unpredictable outputs to a quantitatively controlled process (Siviy, Penn and Harper, 2005; Chrissis, Konrad and Shrum, 2006; Sutherland, Jakobsen and Johnson, 2007).

Methods like Rich Picture Diagrams (RPD) (Checkland and Scholes, 1990) and Business Process Diagrams (BPD) have also been used to improve organisational understanding (Kirschner, 2002; Feilmayr and Wöß, 2016). Ontologies provide another option to form a platform for business process improvement: they can not only capture high quality conceptualisation of the subject domain - such as a complex cross functional business process - but also provide a format that can easy be understood by IT experts (Partridge, 1996; Guizzardi, 2005; de Cesare and Geerts, 2012; Dijkman, Rosa and Reijers, 2012).

There is, however, not one single modelling technique that addresses all the organisational needs, such as upper management, process stakeholders, or models allowing the implementation of IT solutions. With regards to business processes and modelling, specific gaps can be identified in the literature: firstly, a lack of research as to how business processes requiring several modelling techniques for different operational needs should be addressed. Secondly, research into how modelling techniques build on each other and can be integrated to reflect different representations of the same process is missing. Both those aspects will be considered in this research, to address a problem encountered in industry which can summarised as follows:

- Business processes are rarely modelled with the end user in mind which leads to reduced engagement and thus ability to identify problems. Stakeholders have often an excellent knowledge of the process and their involvement is paramount Dijkman, Rosa and Reijers, 2012; Fleischmann and Stary, 2012; Van Nuffel and De Backer, 2012; Kathleen, Ross and Kriglstein, 2014; Bitkowska, 2017)
- Several different modelling approaches and techniques can be found, each with their own benefits and weaknesses - the choice of the correct method for the organisational need is important, yet there is limited understanding how to best do this (Aguilar-Savén, 2004; Tangkawarow and Waworuntu, 2016) and the choice of the technique

- It can be challenging to choose a technique that meets the organisational purpose, but it is crucially important to identify this purpose early on to make the right choice
- The same business process might require more than one model using different methods to address specific organisational needs. The choice of model also depends not only on its intended purpose but the desired maturity level (Aguilar-Savén, 2004; Rosemann, 2006; Van Nuffel and De Backer, 2012).

1.2. Research aim and objectives

The aim of this research is to provide a framework that addresses different levels of business process abstraction. This framework will address different maturity levels and organisational purposes of one selected business process.

The research objectives are as follows:

(1) Perform a critical literature review in order to identify suitable modelling techniques that cover all maturity levels and organisational purposes and use this as a basis to propose a framework

(2) Capture process based organisational data of one selected cross-functional process currently deployed within the research setting

(3) Create and validate the framework upper level, the process overview, by modelling the selected business process using Rich Picture Diagrams

(4) Create and validate the framework mid-level, application view, by modelling the selected business process using Business Process Model Notation

(5) Create and validate the framework lower level, semantic view, by modelling the business process using 4D ontologies

1.3. Research environment: a vehicle manufacturing plant in the UK

In 2002, the vehicle manufacturing company started the project Systematic Process Improvement within the Technical (T) divisions (SPVT). The goal of this project was to define and improve the company's Electrical and Electronic (EE) Processes by following the Capability Maturity Model Integration (CMMI) process improvement approach. Within CMMI different process areas are defined which a company can choose from in order to improve its performance within an area of business, as discussed above. The current CMMI based process landscape does not include process monitoring and relies on lessons learned exercises to be carried out for identification of process improvements. In addition, the processes are not well communicated within the organisation or documented for easy use. This does not provide a foundation for structured process monitoring and necessary process improvements.

The research will be applied to the Process Planning process area and its Production Process Planning and Validation process in a vehicle manufacturing plant. This process is designed to provide the Plant with a vehicle EE test infrastructure, for both new vehicle projects and current series changes. It defines and creates the test content as well as the infrastructure within the plant that is needed to carry it out. The Test content is defined and created based on technical requirements of the entire vehicle. It is thus based on validation requirements of electrical connector connections, Electrical Control Unit programming and the initialization of Electronic / Electrical components.

1.4. Research methodology

Design Science Research (DSR) was used as the methodology with the goal to create an innovative solution to a problem in form of an artefact of constructs, models, methods or instantiations. DSR was chosen was based on the following considerations: the research was carried out within an organisation and the goal was the creation of an artefact to solve a defined problem (Peffers *et al.*, 2008). In addition, DSR is both a product and a process itself, where knowledge is continuously refined throughout. DSR provides a structured approach for the researcher to follow and the others to track and evaluate. It starts with the identification of a problem, followed by objectives that a solution would have to satisfy and the design and evolution of the artefact within a problem domain. The research findings should then be presented for academic appraisal (Hevner *et al.*, 2004; Geerts, 2011; Gregor and Hevner, 2013).

DSR aims to bridge both conceptualisation and practice and uses an iterative design-based approach that creates artefacts which solve the research problem. Each iteration consists of build and evaluation cycles, thus acquiring new knowledge and learning which is the used during subsequent iterations. As part of this research, individual constructs are created using Iterative and Incremental Design (IID) since the overall soliton is complex and large in nature (Larman and Basili, 2003). A slightly modified DSR process was applied which appeared more pragmatic and applicable for this research (see Figure 1-1 for details of research steps). IID was applied using different techniques to create models of a cross functional process, with the following three iterations:

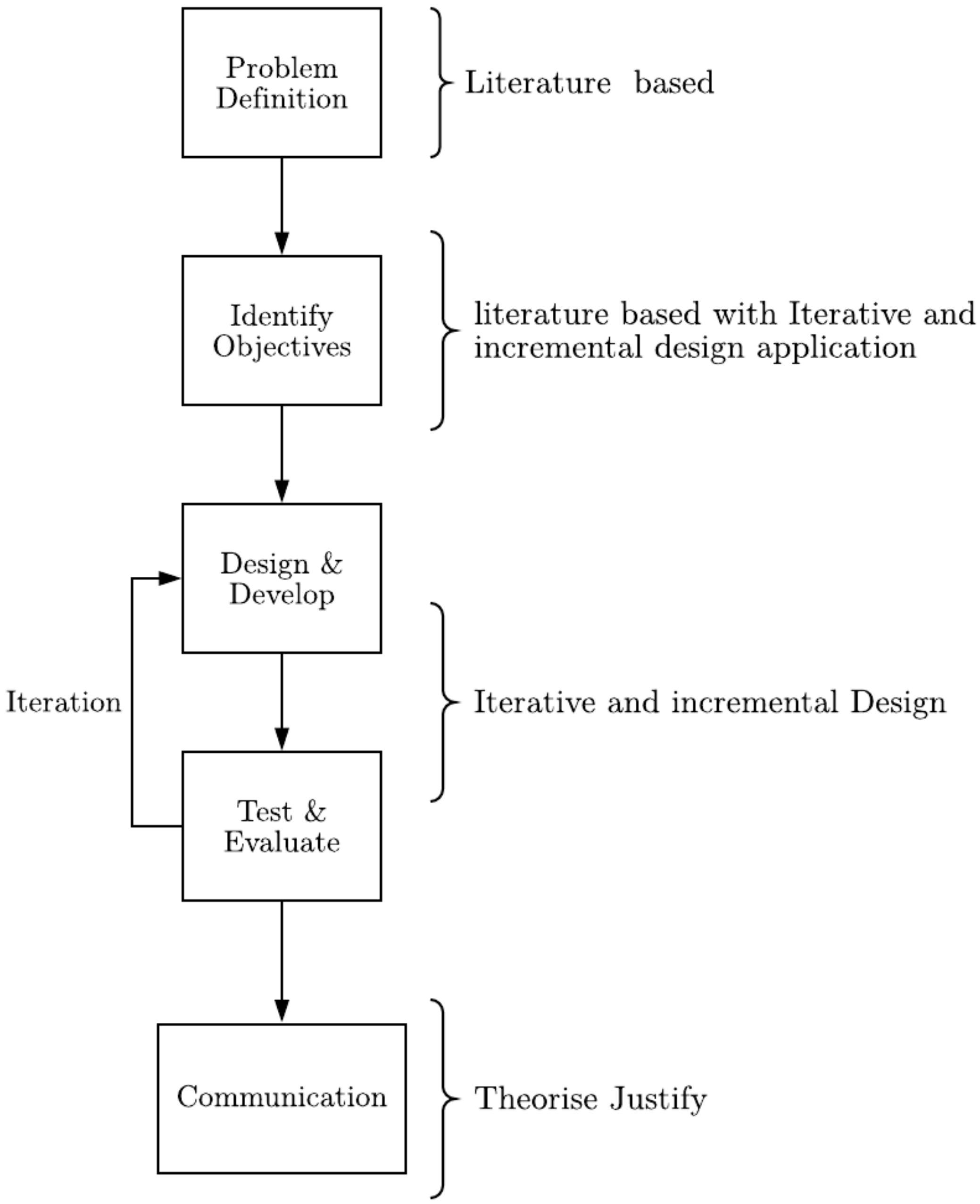


Figure 1-1: Research methodology
Overview of the applied DSR methodology process

1st iteration used semi-structure interviews to create Rich Picture Diagrams (RPDs) and to develop the artefact of a process overview. This provided a new instantiation of the usage of RDPs and creating a *process overview* as part of an overall framework.

2nd iteration used Business Process Model Notation (BPMN) to create Business Process Models providing an *application view* of the process. Learning from the first iteration was applied in conjunction with semi-structed interviews to model the process with a division into activities and task view.

The final, **3rd iteration** used the learning outcomes form the previous iterations as part of its specification gathering to develop 4D business process ontologies using Business Object Reference Ontology (BORO). This also included a literature-based approach to aid and structure the ontology creation process and develop competency questions that can be used to evaluate the ontology. This completes the framework by providing a *sematic view* of the process.

1.5. Thesis structure

To achieve the outlined aim and objectives, the thesis follows the following structure:

Chapter 2

Chapter 2 is a review of the literature which first explores the history and evolution of business processes, as well as their role in modern industry to structure workflow, support improvement activities and process re-engineering. An overview of the use of 'best practice' within Multinational Corporations is given and provides context to the present complexity in nowadays business processes. The chapter contrasts how the longstanding history of use of business process and their widespread use within rapidly evolving industries have led to a multitude of poorly designed and understood processes, thus impacting their execution and potential for improvement. While processes are now more common, this does not mean that industry uses them to their most advantage. Multiple business process modelling techniques created to allow industry to manage processes better are discussed; the concept of maturity models is introduced. The chapter draws the conclusion that there is not a single modelling technique that can provide an organisation with what is needed. Three modelling techniques (Rich Picture Diagrams, Business Process Model Notation and 4D ontologies) are then identified that have the potential to address the width and breadth of what an organisation might require to capture the complex relationships between process elements within the ever-changing business environment.

Chapter 3

This chapter introduces Design Science Research (DSR) as a suitable methodology for this research. DSR allows to focus on design when developing constructs that improve the problem domain, whilst also being able to theorise and justify how the constructs perform. The chapter then discusses the application of DSR within the research project setting, as well as the methods used. It also discusses the details of artefact design and development and how an Iterative and incremental design is the appropriate approach for creating a framework combining several modelling techniques. The chapter further introduces the used DSR process and maps out the three iterations against the DSR process.

Chapter 4

Chapter 4 presents the first iteration based on the application of DSR to create a process overview using Rich Picture Diagrams. It reintroduces the iteration's objectives to gather organisational data and to create a process overview. An in-depth description of the researched cross-functional process is provided and the iterative design approach for the creation of the artefact is introduced. Detailed discussion of the use of semi-structured interviews during artefact development follows. The chapter discusses how the models evolve throughout the process, highlights important learning points and evaluates of the created process overview. The chapter concludes by providing the first level of the proposed framework in from a process overview.

Chapter 5

This chapter covers the second Design Research iteration creating an artefact in the form of an application view of the process using BPMN is presented in Chapter 5. The objective of creation of an application view of the process using BPMN is reintroduced. The chapter demonstrates how learning outcomes from the first iteration are incorporated into the design and development. Again, a detailed overview of the use of iterative design approach and semi-structure interviews to develop the final artefact is provided. The benefits of segmentation of the BPM is contrasted with having one large model. The chapter concludes with an evaluation of the application view artefact and a discussion of the learning points. Finally, the 2nd level of the proposed framework in from an application view is provided.

Chapter 6

Chapter 6 presents the third and final Design Science Research iteration with the objective to create a sematic process view using a 4D ontology. It introduces BORO as an upper level ontology and uses learning from the previous iterations to builds on. The learning from Chapters 4 and 5 is incorporated into creating the specifications for the development of ontologies. The chapter introduces a literature-based ontology creation process, which is then applied to develop the final artefact and test and evaluate it. All steps of the ontology development are discussed in detail, with particular focus on motivational scenarios and the development of Competency Questions and their role in validation. The chapter concludes by discussing different options for ontology validation before providing an overview of a graphical approach to validation using the set-out Competency Questions. The final artefact is a Business process ontology and provides the 3rd and final layer of the framework.

Chapter 7

This chapter concludes this research thesis by presenting the contributions, key findings but also limitations. It provides a discussion of the findings from the previous chapters in the context of current understanding of business process modelling. It also discusses the limitations and advantages of the approaches used in this research project. An evaluation of the DSR process against the research aim and objectives is provided. The research limitations are discussed and explained with suggestions how future improvements could build on those shortcomings. A brief discussion of potential further development of 4D ontology models and representation using IT systems is included. The chapter concludes with suggestions for potential future research and how encountered difficulties could be improved on.

Figure 1-2 provides a thesis outline diagram which maps the Design Research iteration to the chapters of the thesis. The diagram also highlights how research objectives are addressed throughout the thesis.

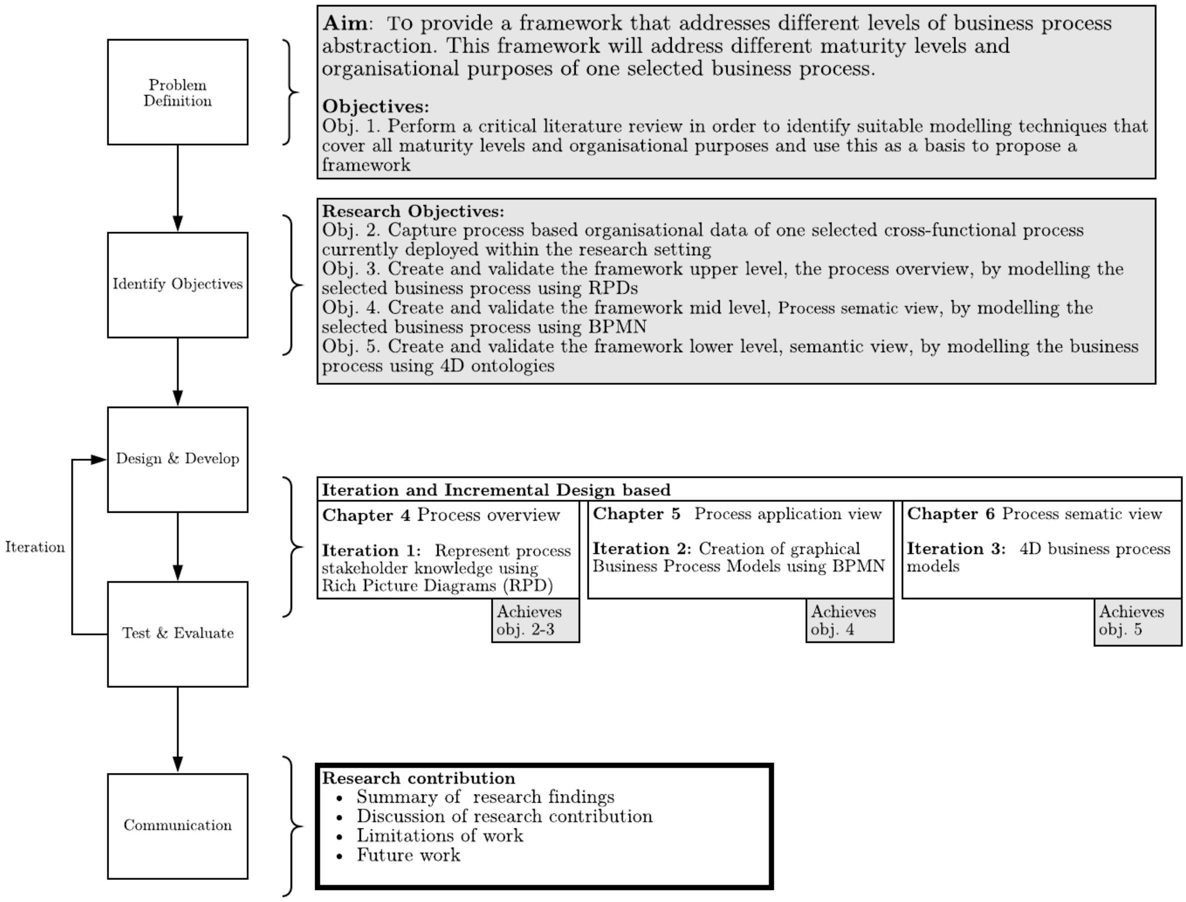


Figure 1-2: Thesis Outline

Maps the research aim, objectives and iteration to the chapters of the thesis

Chapter 2. Literature Review

2.1. Introduction to Business Processes

As early as 1776, Adam Smith described the breakdown of the production of a pin within the pin factories across England, thus defining division of labour as a possible solution to increase productivity (Smith and Cannan, 1922). His separation of the production system into individual tasks is one of the earliest descriptions of a process. This subdivision into smaller tasks for each involved individual in the production was important in improving quality and productivity of the factory overall (Smith, 1776; Becker and Murphy, 1992; O'donnell, 2016). The industrial revolution allowed many European countries to continue to flourish due to the increasing economic wealth, which drove development in other areas such as healthcare, sanitation and education (Godfrey and Julien, 2005; Konteh, 2009).

Throughout the 20th century, division of labour and the definition of processes in the context of industrial production continued. As the use of business processes became more widespread and better understood, the processes themselves needed to improve. This led to a business process improvement initiative, following the Second World War. The philosophy (see Figure 2-1) behind the Toyota Production System (TPS) was one of the vehicle industry's first attempts to assess business processes and minimising waste, aiming for "lean production" in the terms of TPS (Krafcik, 1988; Liker, 2003). Many believe that it was this philosophy, which is responsible for the success of the Japanese car manufacturer worldwide (Spear and Bowen, 2006).

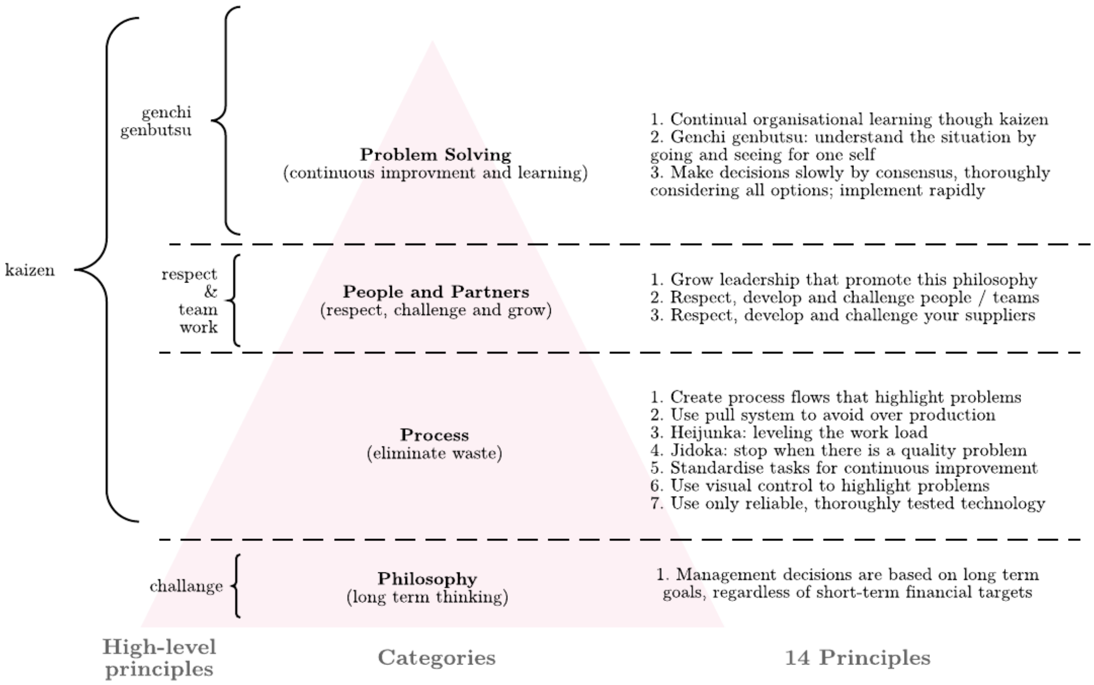


Figure 2-1: TPS 4P model
14 principles that from the foundation on which TPS is built on, adapted from (Liker, 2003). The pyramid shows how each category and its principles builds on one another and how the high-level TPS principles can span over multiple categories.

Ever since TPS, the industry has embraced continuous business process improvement, although not everyone might follow the same Japanese culture and core philosophy. Today, the vehicle manufacturing industry is one of the biggest industries worldwide, with an annual industry revenue of more than $1.8T it is the 6th largest industry in the world (Bloomberg, 2016).

In 1993, Hammer and Champy (Hammer and Champy, 1993) coined the idea of ‘process re-engineering’: the analysis and re-design of business processes to help cut costs and improve customer satisfaction based on a cross-functional assessment. The concept is based on the idea that certain aspects of large-scale work need to be assessed for their value before automating them (Hammer, 1990). Thorough understanding of all processes in detail is crucial to be able to identify components which offer no added value (Laguna and Marklund, 2013), and modelling techniques can be used to improve process understanding in the first place (Curtis, Kellner and Over, 1992; Andersen, 2007; Hammer, 2007).

Process re-engineering often represents a rather radical approach in contrast with Davenport's concept of business innovation and improvement: it describes a subtler and iterative approach. In his view, the improvement starts with the identification of appropriate processes and "is a natural follow-on to documenting them" (Davenport, 1993, 2010). More than 20 years ago, Davenport recognised the potential of using the expanding field of information technology for process improvement - an idea that remains current.

Today, business processes are part of corporations of all sizes and different industries. Business Process Models (BPM) are well established within economics teaching and industry day-to-day businesses. As with Adam Smith's initial description of a work process, the modelling of any workflow using a process allows for improved organisational understanding and is aimed to improve quality whilst lowering production cost (DaSilva and Trkman, 2014). However, not all corporations take equal or fullest advantage of business process modelling tools and methods available (Curtis, Kellner and Over, 1992).

The so-called 'superhero solution' refers to personnel which can carry an organisation and its processes and challenges (informal communication within organisation). Often, the existence of such a role is a symptom of the organisation's processes not being well established – this can lead to a dangerous situation in which the organisation becomes dependent on this particular role and individuals fulfilling it. With all this in mind, one of the purposes of defining a process within an organisation is to remove the need for a 'superhero' and return to the idea of well-established processes that the average stakeholder can understand and implement. Dating back to 1999, Toyota Motor's President Cho announced, "We get brilliant results from average people managing brilliant processes, while our competitors get average or worse results from brilliant people managing broken processes" (Oakland, 2014).

2.1.1. Business processes and Multinational Corporations

Multinational corporations (MNCs) based in several countries are becoming more and more common. Global representation allows MNCs to increase growth and maximise profit: foreign markets can be more accessible (e.g. import tax, legislation or transport cost) and production cost can be reduced by operating in a foreign country (Root, 1994). An increasing number of corporations have fewer assets and employees based in their country of origin than in their international subsidiaries. These changes lead to the development of established global project teams promoting a "best practice" work approach (Smelser and Baltes, 2001) and its documentation. This is captured using processes defined by Hammer and Champy as a "Set of partially ordered activities intended to reach a goal" (Hammer and Champy, 1993; Aldin and de Cesare, 2011).

MNCs aim is to use economies of scale by initially defining a best practice approach. Ideally, this defined best practice approach then becomes a set of processes that are carried out in all subsidiaries. To ensure that the process is designed and implemented correctly, it is monitored continuously to highlight areas in need for improvement. The identified necessary improvements are then taken into consideration once the process enters its next life cycle. The organisations must be able to control their complex processes in order to not only increase productivity and remain cost effective, but also to satisfy its quality standards (Letsholo, Chioasca and Zhao, 2012).

As business processes are becoming more common, the overall number or processes modelled in increased. In addition, the complexity of the models has increased as they have become more used within a changed (and more complex) industrial world. It appears that currently there is pressure towards creating large volumes of processes in short time frames. Ideally, process models should be seen as documentation created with the people in mind who use this process – thus focussing on helping the user to understand what their role is and allowing the organisation to identify areas for improvement. Poorly designed processes are less well understood, which contributes to poor implementation and lack of establishment within the company (Rosemann, 2006; Letsholo, Chioasca and Zhao, 2012).

Following on from discussing the history, development and ideology behind business processes and the consequences of an industry with MNC, it can thus be hypothesised that the current environment is facing several challenges relating to business processes and their modelling:

(1) The complexity of today's business processes is at a new high
(2) Novel processes are likely to be cross functional
(3) Processes are often *not* modelled with the end-user in mind
(4) Processes are often defined by personal without formal training in process design
(5) Processes are commonly defined within an organisation ('in-house'), therefore not necessarily using existing industry standards.
(6) Processes affecting MNCs located in multiple countries need to account for different educational and cultural backgrounds as well as different local organisational needs.

The combination of these problems can lead to a situation where processes and process models exist for bureaucratic reasons, which consume additional resources rather than adding value to the organisation.

This outlined practice therefore interrupts the Business Process Improvement cycle by creating processes which are not understood and not followed, therefore creating a mismatch between processes and actual working practices. It is common that processes are initially defined as part of an implementation initiative, however after that are left unattended and deviate from actual working practices (Van Nuffel and De Backer, 2012).

Whilst several of the issues outlined above cannot be changed, e.g. the level complexity and cross-functionality of current processes, the focus ought to be on improving those aspects which can be addressed or influenced. Exploring how to present a process in a way that allows understanding by the end-user and within the organisation is therefore crucial.

2.1.2. The role of stakeholder's involvement

Despite the described complexity that MNCs have introduces to business process, we need to remember that business process stakeholders are key to each and every business process within a large corporation. Process stakeholders can be defined as anybody who has a stake in the process, i.e. the process owner or anyone who provides an input, receives an output or carries out any task, which forms part of the process (Kim and Ramkaran, 2006). Stakeholders possess the knowledge not only to describe the process they are involved in (Bitkowska, 2017), but are also the first to recognise problems.

Documented business processes (a business process model) are method to capture organisation knowledge of a process and allow it to be shared, learned from and used as a basis for decision making (Bitkowska, 2016). Secondly, for an organisation to benefit from the captured knowledge (of a business process, in form of a model) we need to look beyond the direct stakeholders of that process: all individuals of the organisation should be able to interpret the information relating to the processes. Therefore, good communication and use of a common 'language' is paramount to enable e.g. interactions with other processes within the organisation, learning and improvement (Andersen, 2007). This allows cross-functional discussion within the organisation and interaction (and improvement) by expert teams across different specialties. Finally, for higher management to be able to make strategic decisions, they need to also be able to understand and interpret the business process (model). To have one common business process model which allows all those interested parties and stakeholders to gather the information they require is not a simple undertaking (Davenport, 2010) .

Ensuring organisational understanding of its business processes is therefore an important factor that needs to be looked at more closely. The implications of the process being misunderstood could lead to an incorrect execution and failure of improvement initiatives (Hammer, 2010). Therefore, business processes need to be available in a form that can be easily and correctly interpreted – alternatively the reason for their existence is questionable.

In addition to capturing and displaying the process so that it can be easily understood, it is worth exploring future organisation needs, such as moving from business improvement to optimisation. Furthermore, there is a strive to optimize processes though Business Maturity Models (BMM), such as applied Capability Maturity Model Integration (CMMI) within the investigated company (Siviy, Penn and Harper, 2005; Chrissis, Konrad and Shrum, 2006; Sutherland, Jakobsen and Johnson, 2007). The goal is to move away from improving (qualitative) to optimising (quantitate) business processes, and to be able to achieve this, there is a need for a systematic approach, which is able to identify process bottlenecks. Paving the way for this are Business Process Intelligence tools for statistical analysis and prediction tools (Dayal, Hsu and Ladin, 2001; Grigori *et al.*, 2004; Lee, Lee and Kang, 2007).

2.2. Business process modelling techniques

2.2.1. Business processes and maturity levels

As part of the drive to for the organisation to improve their process they need to be captured. Initially the trend has been for business analysists to re-engineer processes with the goal of high efficacy gains; during this period there would be push for the organisation to improve efficacy and quality through such initiatives as Total quality management, which captured and analysed processed to improve and sustain quality primarily within the manufacturing sector.

Macintosh (1993) summaries process maturity in 5 different levels based on industry standards, the US government and Carnegie Mellon University. CMU and the US government then went on to develop of the business maturity model CMMI (a guided organisational process model).

The basis for this can be summarised in different maturity levels:

(1) Initial; process is being created

(2) Repeatable; process is repeatable

(3) Defined; process captured

(4) Managed; process monitored and controls in place

(5) Optimised; bottlenecks identified and rectified

Maturity levels 1-3 require process models that allow for analysis, whereas levels 4-5 support decision making that allows for process monitoring and ultimately control (Macintosh, 1993; Aguilar-Savén, 2004). Firstly, focusing the discussion on capturing the process: A process model's goal is to capture the "real world" and improve process knowledge by deconstructing organisational complexity. The difficulty lies within understating and capturing the "real world" in a way that the organisation can use it to either learn from and or make decisions from. It is, therefore imperative to involve the audience and stakeholders in the creation of models can further aid understanding (Chandler and Sweller, 1991; Kirschner, 2002; Bitkowska, 2017).

2.2.2. Review of business process modelling techniques

The case for creating and capturing process models has been made, though not as to how to successfully implement them. There are multiple business process modelling techniques to choose from. In their most basic form, processes help to clarify how and what you are doing and then look simply at inputs, tasks and outputs. These days, however, we use additional elements such as stakeholders, tools, communication channels and multiple sub levels of processes. These elements are used in process models, which can range from formal mathematical models to informal non-standardised flowcharts, or text descriptions (Letsholo, Chioasca and Zhao, 2012; van der Aalst, 2013; Bitkowska, 2017).

The different ways processes are displayed depends on what purpose the model serves, ranging from mathematically based modelling techniques for simulation and optimisation to descriptive models for organisational knowledge sharing and improvement (Curtis, Kellner and Over, 1992; Aguilar-Savén, 2004). Using mathematical process models can be suboptimal due to their inherit complexity, and counterproductive when it comes to improving understanding; therefore descriptive models are often preferred as they improve understanding and learning (Van Nuffel and De Backer, 2012). In contrast, visual representations are particularly easy to understand and can form a foundation for discussion and process improvement, as well as more formal modelling and documentation. The problem industry faces is that not only does it need to understand *what* it wants to model and *why*, but also choose from a multitude of modelling techniques and tools.

Aguilar- Savén provides a review and framework to categorise modelling techniques (Aguilar-Savén, 2004): It categorises them with the intention to allow the modeller to make a selection based on what problem they want to solve. It divides the purpose of the model in categories such as improving organisational learning, process development, process simulation, defining IT requirements. Techniques are then overlaid over one or a mixture of several of categories, providing an overview of which technique fits the propose of the model. In addition, it divides the techniques into either passive or active techniques, describing the level remodelling required when making changes (see Figure 2-2). This work provides a comparison between Rich Picture Diagrams with other more established modelling techniques; however, does not classify it as creating a model that is descriptive, i.e. provides learning. Arguably, it was designed to provide an organisation with a simple representation of more complex situations, so that it can learn from it (Checkland, 2000; Siau and Wang, 2007). This review and framework offer a clean descriptive comparison across categories. However, it is at time difficult to follow the rationale for how some techniques were mapped across the domains.

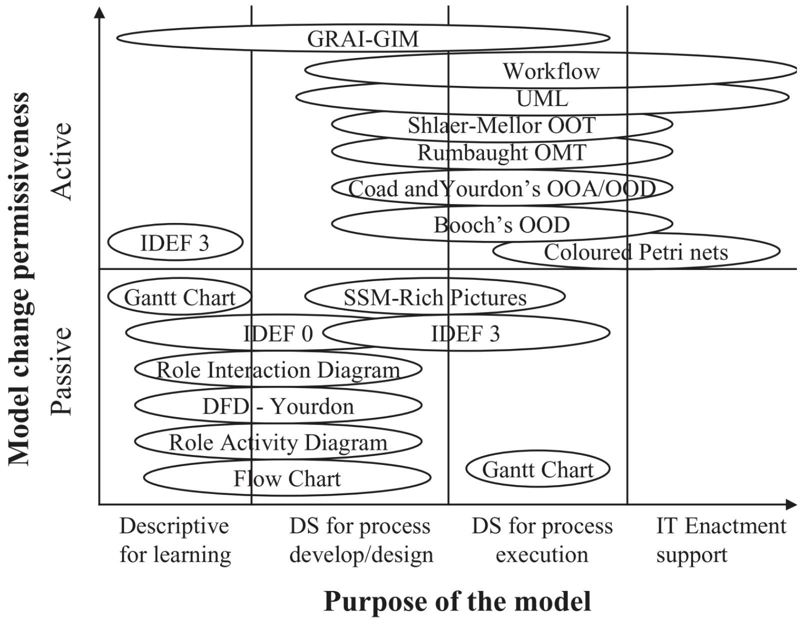


Figure 2-2: Reference Framework
Maps process modelling techniques over multiple categories (Aguilar-Savén, 2004)

Another approach to compare and contrast modelling techniques is described by the Bunge Wand Weber (BWW) model which aims to measure and evaluate the ontological completeness of modelling constructs. It allows for a comparison between the domain and modelling constructs and thus provides a method to analyse modelling techniques, as has been done for 10 techniques in the past. Recker *et al* (Recker *et al.*, 2009) use a BWW model-based approach to include an evaluation of the recent techniques BPMN and Perit nets to the comparison of previous 10 (see Table 2-1). Although this method provides a structured approach for evaluation modelling techniques, Aldin and de Cesare (2011) argue that upon review of previous applications that there is an underlying lack of understanding of BWW model constructs, their application and finally their analysis.

In addition, in order to the carry out this type of analysis, good understanding of the BWW ontological method itself, as well as individual modelling techniques under evaluation are required (Aldin and de Cesare, 2011). In summary, whilst BWW model can be used to generate a comparison and a score of different techniques, the scores need to be interpreted carefully and put into context. A third method for comparison was used by Tangkawarow and Waworuntu in a review of four modelling techniques based on syntax (Tangkawarow and Waworuntu, 2016).

Modeling technique	**Petri net**	**ANSI flow-charts**	**DFD**	**ISO TC87**	**Merise**	**EPC**	**IDEF3**	**ebXML**	**BPML**	**WSCI**	**WS-BPEL**	**BPMN**
Version								*1.01*	*1*	*1*	*1.1*	*1*
Total degree of deficit	58.6 %	93.10%	72.40%	75.90%	62.10%	62.10%	62.10%	27.60%	65.50%	48.30%	48.30%	34.50%
Total degree of completeness	41.4 %	6.90%	27.60%	24.10%	37.90%	37.90%	37.90%	72.40%	34.50%	51.70%	51.70%	65.50%

Table 2-1: BWW model
Comparison of modelling techniques using BWW model table summary from Recker *et al.* (Recker *et al.*, 2009)

They model the same process using different techniques. For each technique, strengths and weaknesses based on the use and interoperation are provided. Their work provides a detailed overview on each evaluated modelling technique and their syntax, though it misses a structured comparison between them. Additionally, there seems to be a lack of guidance on how to determine what modelling technique to use.

A point that comes up multiple times in literature is that all depends on not only on what you want to model, but also on what you want to *achieve* by doing so (Aguilar-Savén, 2004; Tangkawarow and Waworuntu, 2016). In addition, factors such as the modelling technique chosen are based on individual choice more commonly determined by tool availability, comfort of use and/or familiarity (Rosemann, 2006). Most companies and organisations have traditionally developed methods of communication and record keeping to document processes. However, it is difficult to make an assessment of how many of the methods used enable true organisational understanding, moreover whether the methods used have been adapted and altered in-line with theories of business process modelling (Curtis, Kellner and Over, 1992).

For this research, three methods were chosen to allow for comparison and application across different domains: BPMN as the industry standard, and Rich Picture Diagram and 4D ontologies. The use of these three methods also represents extremes from simplest to most challenging (and innovative) for industry. The next section discusses their methods of modelling a process in more detail, with a short overview of their development and structure.

2.2.3. Rich Picture Diagrams

The Rich Picture (RP) Diagram is not a BPM *per se* but a modelling technique, initially introduced to allow capturing the perceived world in a sketch-like form without any formal boundaries, as part of Peter Checkland's Soft System Methodology (Ormerod, 1999; Checkland, 2000; Baskerville and Dulipovici, 2006; Sutrisna and Barrett, 2007). The idea behind the RPD is to create a simple representation of more complex situations, such as socio-political interactions within an organisational system (Siau and Wang, 2007). Pictures can be used alongside text, creating a format that is readily understood by the end user. In addition, the business end users can further contribute to improve the RP and their understanding of the problem or situation.

The underlying structure is based on the three main elements, (1) structure, (2) concerns and (3) process (Monk and Howard, 1998). The structure relates to things that are slow to change within an organisation, such as its IT systems, its organisation hierarchy and its physical location. This includes stakeholders that are affected by any changes. The second element (concerns) allows for any concerns to be highlighted within the diagram, such as tension, stress or conflict. The final element (process) focuses on activities, their inputs and outputs and who is carrying them out (see Figure 2-3 for example).

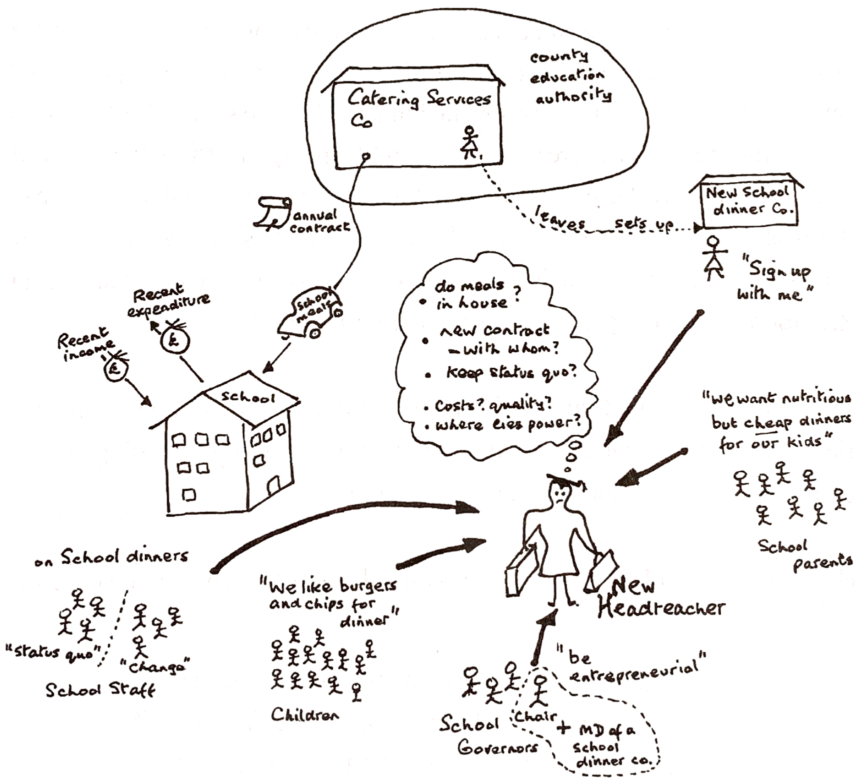


Figure 2-3: Rich picture example

Rich picture example form Checkland describing the socio-political view of a new head teacher (Checkland and Poulter, 2006)

RPDs are traditionally composed by use of interviews, incorporating organizational language. The use of appropriate drawings and text aids individual and common understanding (Avison, Golder and Shah, 1992; Monk and Howard, 1998; Checkland, 2000; Sutrisna and Barrett, 2007).

2.2.4. Business Process Modelling Notation (BPMN)

To communicate and aid the learning of business processes within an organization, a graphical representation can provide a strong solution (Bera, 2012). It allows for a more intuitive representation, which is easy to understand in contrast to textual or mathematical models (Owen and Raj, 2003; Recker, 2010) .

One of the most well-known examples of a graphical process representation is BPMN (Business Process Modelling Notation). It originated from an initiative to create a standard modelling notation for business process models (White, 2004; Bera, 2012).

Based on the idea of a flowchart, it uses symbols that are commonly recognised within today's organisations (see Figure 2-4). It provides a framework and therefore a structured approach, which allows modellers to easily create business process models that are clear enough to be understood by business users across different organisations (List and Korherr, 2006; Aldin and de Cesare, 2011). Although it may be easy to understand it can still provide challenges to model using BPMN, and thus different users can create different models for the same process (Tangkawarow and Waworuntu, 2016)

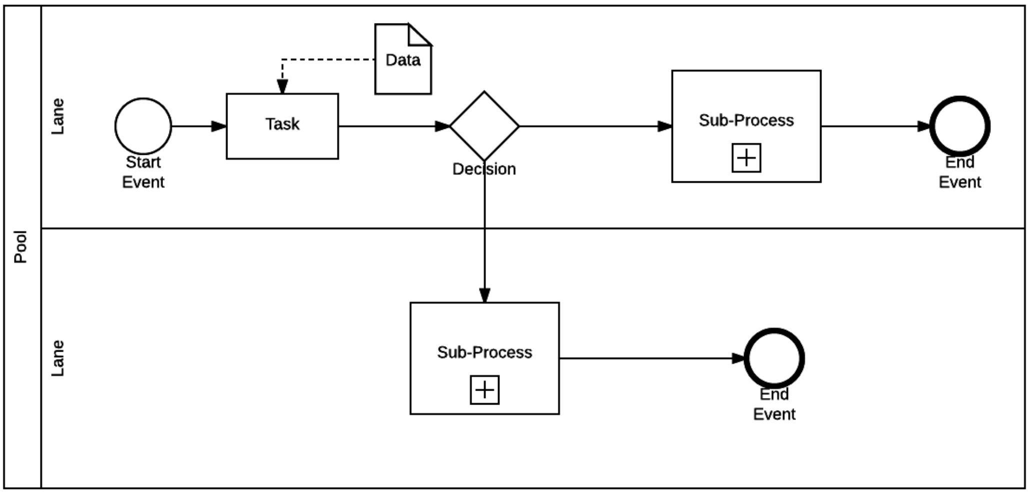


Figure 2-4: Examples of symbols used in BPMN to model a process

2.2.5. Foundational Ontologies

An ontology is a way of viewing the world, it provides a way of specifying the world that we want to represent. It is a way of conceptualising ones' environment, originated from within the philosophy which aims at understanding e.g. an object in its complexity and all its relations to the environment (Partridge, 2005; Zalta, 2010).

Modelling languages determine the quality of conceptual representation of a subject domain. The more complex the subject domain, such as modern cross-functional business processes, the more difficult it is to capture a precise representation. This conceptual representation, or model, can be used as a foundation for development of IT systems, such as semantic business process modelling (SBPM). A precise conceptual model provides a solid platform, which improves the IT systems quality and reduces development time (Guizzardi, 2005; de Cesare and Geerts, 2012; Dijkman, Rosa and Reijers, 2012).

The use of the concept of ontology allows for a richer representation of business models. This makes them superior to conventional business entity models, which struggle with defining temporal objects (Partridge, 1996). Due to the nature of gradual business process development within organisations it becomes important to not only monitor current changes, but also changes to previous changes (Aldin, de Cesare and Lycett, 2010). A 3-dimensional (3D) paradigm in acknowledging objects, their attributes and relationships and considers them to remain constant throughout time. 4-dimensional (4D) ontologies add a temporal dimension and define objects “the mereological sums of temporal parts” (McCall and Lowe, 2006), i.e. an object that is defined by the sum of multiple elements existing within a *defined* time frame. This concept can sometimes be difficult to understand, but an example would be to consider Person A (and their 3-dimensional attributes): throughout his lifetime, Person A assumes different roles such as a school student, a university student and a scientist – each in a defined time frame. 4D ontologies can be described using a philosophical approach (Zalta, 2010), however this does not necessarily ease the understanding. A different attempt to explaining 4D ontology can be to use an umbrella - the object is made up of the following spatial extensions: the canopy, a ribs assembly (stretcher), hub and a shaft. The consideration of 4D allows to capture an object’s condition change by using temporal parts. For example, an umbrella can either have the temporal state of being close or open. Its spatial extensions (e.g. The umbrella’s canopy) also change their temporal states at the same time, depending on the level of abstraction in which the object is viewed. The questions we as users of the technique have to decide, is whether it is sufficient to understand simply what is meant by a closed umbrella, or do we need to include in this description the exact positions and movements of all spatial extensions? Looking at the most basic level of the spatial parts, in this example the canopy opens when the rib assembly unfolds, and as the stretcher is pushed up to a high position on the shaft – thus providing more information than a simple distinction between 'open' and 'closed' state.

2.2.6. Business Objects Reference Ontology (4D Ontology)

The Business Objects Reference Ontology (BORO) is a method which can be used to represent 4D ontology, developed by Partridge in the early 1990s. It allows the capturing of complex relationships between objects, their special extensions and their temporal parts. It describes a structured approach for capturing these organisational ontological elements; this method also provides improved the quality of the semantic model it creates. It makes use of the fourth dimension, which provides the object and its spatial extension of temporal parts with states, i.e. each object is made up of temporal parts. Taking the temporal extensions of objects into account when modelling it, provides not only simpler but also a more acute conceptualisation of the ontology compared to a three dimensional one. The three-dimensional ontology is limited, since it cannot conceive the changes within an objects temporal extension, e.g. an object would either be conceptualised as one state or the other and therefore have trouble with representing the change and the relationship between the previous state (Partridge, 1996; Cesare and Partridge, 2016).

4D ontologies focus on exploring future organisation needs, such as moving from business improvement to optimisation. Furthermore, there is a strive to optimise processes though Business Maturity Models (BMM), such as applied Capability Maturity Model Integration (CMMI) within the investigated company (Siviy, Penn and Harper, 2005; Chrissis, Konrad and Shrum, 2006; Sutherland, Jakobsen and Johnson, 2007). By changing business process from qualitative/improving to quantitative/optimising we accept a need for a systematic approach that requires Business Process Intelligence tools for statistical analysis as well as prediction tools (Dayal, Hsu and Ladin, 2001; Grigori *et al.*, 2004; Lee, Lee and Kang, 2007).

Fan *et al* (Fan *et al.*, 2016) argue that, the creation of BPM itself creates a high cognitive load and an easier approach would be to create business process ontologies first. Their argument is that the language used in ontology creation is easier to understand and that good business process models require a higher level of cognitive load (as well as understanding) during the creation.

The application of ontologies allows this by capturing both the relationship between elements, and any relationship changes over time. This then allows to answer queries such as what is the effect when, who carries out an activity, what specific activities does a role carry out, how this compared to a previous time point (or time points), what tool(s) are required to carry out these activities etc. The way the information is gathered is based on certain scenarios or situations of interests. The use of ontologies allows to use a 'language' that can be used to build a framework for IT to subsequently implement and build databases around it (Guizzardi, 2005; West, 2009; de Cesare and Geerts, 2012). The application of IT language and implementation is then the next step to use business intelligence tools not only to undertake analysis of the available information, but also to make predictive statements (Dijkman, Rosa and Reijers, 2012).

Table 2-1 provides a comparison of the strengths and weaknesses of RPD, BPMN and 4D ontologies alongside each other.

Techniques	Strengths	Weaknesses	Purpose	Source
Rich Picture Diagrams	- Easy to understand - Support communication - Highly contextual (interactions between different process elements) - Close stakeholder invlovment	- No structured approach - Lack of standard notation - Not suited for structured analysis	- IT Requirements +++ - Process simulation and Execution ++	(Aguilar-Savén, 2004) (Checkland, 2000)
BPMN	- Easy to understand - Ability to represent multiple levels - Ability to model complex processes - Widely used - Good in capturing real world process	- Can become ambiguous - No standard file format	- Organisational Learning +++ - Process Development ++	(Recker, Rosemann and Indulska, 2009) (Tangkawarow and Waworuntu, 2016)
4D Ontologies	-Ability to model complex processes - Strong in capturing real world process - Captures process elements relationships - Captures process instances	- Modelling approach not clear - Difficult to understand - Not commonly used	- Process Development +++ - Organisational Learning ++	(Partridge, 1996) (Cesare and Partridge, 2016) (West, 2009)

Table 2-2: Strength and weakness of selected modelling techniques
Provides an overview of modelling techniques that together span over multiple proposes

2.3. Business process modelling in multinational corporations: problem definition and research scope

This chapter contrasted some of the commonly used modelling techniques, with a description of three attempts to create a comparison of techniques. Multinational corporations and large-scale production rely heavily on business processes, however, do not always use modelling techniques to gain the most beneficial results beyond creating a simple description of processes (Rosemann, 2006). One of the most important decisions is to understand the purpose of the business process models. This step then allows to identify the most appropriate technique. Based on understanding the purpose, the next step is to understand which maturity level (see 2.2.1) is required: to simply create a process (level 1), to define it which means to capture it (level 3), or to create a process that identifies and even rectifies bottlenecks (level 5) (See 2.2.1 for definition of levels). Each desired maturity level sets out different requirements for the process model itself, such as the level of detail to be incorporated in the model. A drive for a higher maturity level aimed at process management and optimisation (and e.g. IT integration) would occur, however, at the cost of reduced basic understanding. Figure 2-5 provides a visual overview of how different techniques address different model purposes and their degree of process maturity.

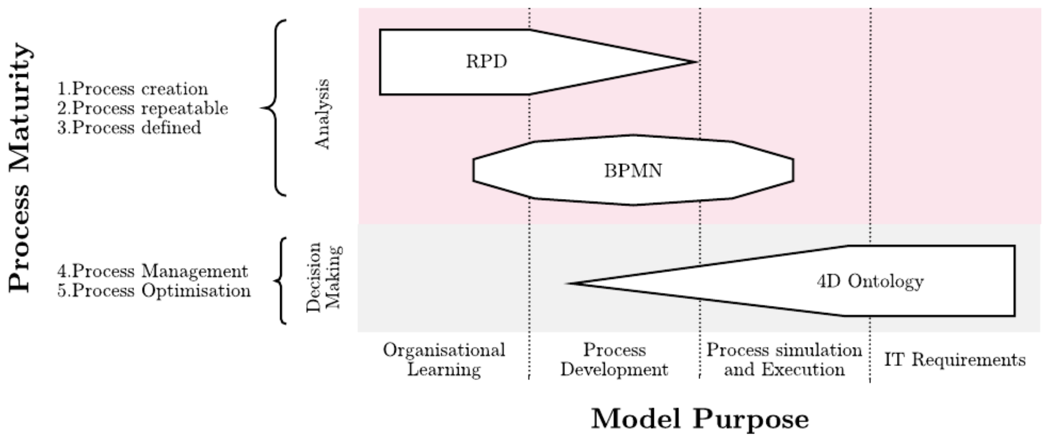


Figure 2-5: Process Modelling Techniques Assessment
Maps selected modelling techniques over process maturity (Macintosh, 1993) and model purpose (Aguilar-Savén, 2004) to highlight their differences and what purpose or maturity they address.

Whilst there are a multitude of other problems with business process modelling (Rosemann, 2006) for the purpose of this research the following problem encountered in industry was identified; it can be summarised by the following aspects:

(1) **Processes are often not modelled with the end user** in mind thus limiting the actual use by the end user. This leads to reduced engagement and inability to detect faults. Involvement of stakeholders in all stages is therefore not only beneficial, but crucial. Stakeholder knowledge is of benefit to create more accurate models, and their input can also be used to validate the created models. Engagement of stakeholders throughout the creation and validation also leads to overall increased involvement and buy-in (Dijkman, Rosa and Reijers, 2012; Fleischmann and Stary, 2012; Van Nuffel and De Backer, 2012; Kathleen, Ross and Kriglstein, 2014; Bitkowska, 2017)

(2) **A multitude of different approaches and techniques co-exists**, each with their individual strengths and limitations, and the choice of an incorrect approach can not only be suboptimal but in fact counterproductive. It can be a challenge to choose a technique that meets the organisations model purpose, yet no clear,

in-depth modelling guidelines on model creation are published (Aguilar-Savén, 2004; Tangkawarow and Waworuntu, 2016)

(3) **The same business process might require more than one model** using different techniques to address the needs and required specific information of different stakeholders such as directorate level (wide overview) compared to line workers or other stakeholders (day to day detailed description), or IT integration; whilst upper management does not require detailed process knowledge, they are more likely to require information that helps decision making or topic escalation. In contrast, process experts might want detailed information to allow them to carry out different tasks and require information how this affects output. IT experts, however, require models that provide them with detailed information to allow implementation of IT solutions to e.g. set up databases. It is impossible to create *one* model that addresses all individual needs (Aguilar-Savén, 2004; Rosemann, 2006; Van Nuffel and De Backer, 2012). The choice of model also depends not only on its intended purpose but the desired maturity level.

The question still remains how an all-encompassing solution would look like and whether it would solve all the MNC's business process problems. Ideally it would reach the highest business process maturity level, i.e. optimisation. Extrapolating from this, it would mean IT systems could be designed so that they capture data each time processes are carried out, are able to interpret the results and put them into context for the organisation to be able to interpret them. Each time a process is carried out this method would allow information on all its elements to be captured over time. This data would not only be used to perform real time monitoring, but also perform advanced analytics so make predictions. Another aspect of this all-encompassing use includes fully integrating organisation by not only managing and creating business processes, but those processes used in day to day discussion, decision making, as well as lessons learned activities. Everyone within the organisation would use the process models that allow them to easily understand details and thus lead to a more effective way of learning and decision making throughout the different levels of the organisation. In an ideal solution, the process models would be created using *one* tool that allows different abstractions to be created so changes to the process models are possible and the required administration is at a minimum. Involved stakeholders who act as modellers would have the right skill set and ability to exchange and use modelling techniques, as required, to create purposeful models.

The creation of such an 'ideal solution' to the problem goes beyond the scope of this research. Some of the reasons to demonstrate how far reaching such an ideal solution would need to include: (1) it would require an organisational culture change which is difficult (or impossible) in a pure research setting, (2) it would require either some existing ("off the shelf") IT solution or creation of new ones from scratch to use 4D ontologies, and (3) it would require existing process models that can be used as a foundation for all other activities and can also capture such outlined IT requirements.

This research project focusses on using design science research methodology to provide a multi-level framework (MFL) that can be used as a possible solution; this framework will provide business process models that cover all maturity levels and corresponding purpose using the three described business process modelling techniques (RPD, BPMN, 4D Ontology), see Figure 2-6.

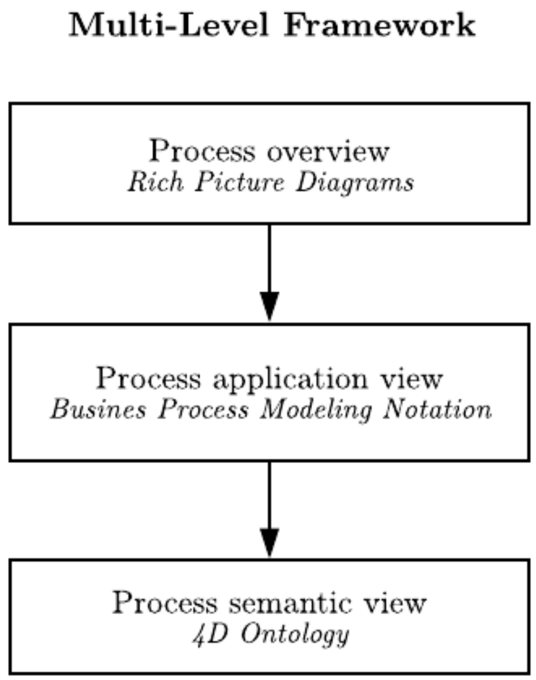


Figure 2-6: Multi-Level Framework
Overview of the MLF and the applied modelling techniques at each level

Chapter 3. Research Methodology

3.1. Design Science Research Methodology

Information systems (IS) are based on understanding and providing context for the research environment.

Research generally follows the path of defining a problem, which can be initially only very loosely defined, followed by a literature review which then aids to generate a hypothesis. Data is then gathered and analysed, and results are discussed and put in context. Different methodologies can be used within IS, such as natural science or design science. Natural science (NS) is descriptive in nature as in it uses literature to generate theories which are then tested for validity. It investigates the how and why and creates knowledge driven by trying to understand and explain observations.

Design Science (DS) has its roots in the areas such as architecture and engineering, with a goal of creating a solution to a problem in the form of a new and innovative design solution in form of artefacts. It produces novel artefacts which fall in one of the following categories: constructs, models, methods, and instantiations – sometimes this takes shape as conventional IT solutions (March and Smith, 1995; Geerts, 2011; Gregor and Hevner, 2013; Heravi, Lycett and de Cesare, 2014). DS can be sometimes criticised as it focuses more on solving a problem rather than understanding it and its context (Baskerville *et al.*, 2018) DSR is a bridge between conceptualisation and practice. It is an iterative design-based approach that creates novel artefacts that have an impact and aim to improve a situation (Ellis and Levy, 2010). Design Science Research is applied research, and as such it is prescriptive: it improves the problem space by creating an artefact. DSR allows for NS theories to be tested, so NS creates the knowledge that DSR in turn aims to solve. The combination of DS and NSR allows to investigate theoretical claims in real world scenarios; it is a pragmatic approach demonstrating that a statement is true if it actually works in practice (March and Smith, 1995). Peffers et al. (Peffers *et al.*, 2008) defined Design Science Research (DSR) in 2008 by defining a framework for the already existing Design Science. DS makes use of both the Behavioural and Design Science research paradigms and thus allows investigating organisational behaviour and creation of artefacts to solve identified problems (Hevner *et al.*, 2004; Geerts, 2011; Gregor and Hevner, 2013).

The principle of DSR was based on providing a solution to an organisation problem with the creation of an artefact that allows it to extend the organisational capability. This solution should be implementable and encourage critical thinking, allowing it to be used in other research problems. DSR was based on three objectives, the first being that it should be constant with existing DS literature. The second that it should provide a process for carrying out design research. Finally, the third rule was to provide research context and structure allowing others to evaluate and follow the research. Essentially, this is based on establishing standalone methodology within IS which does not have to justify its use, but concentrates on its research outcome (Bichler, 2006; Peffers *et al.*, 2008).

March and Smith (1995) created a Framework for DSR to distinguish the different forms that research activities can take and the outputs required when creating a type of artefact (see Figure 3-1) .The combination of all those aspects links natural science and design science to create DSR. This research framework shows a combination of both DS and NS. The first dimension (research activities) is a form of DS, the second dimension combines DS (design, evaluation) and NS (theorise, justify).

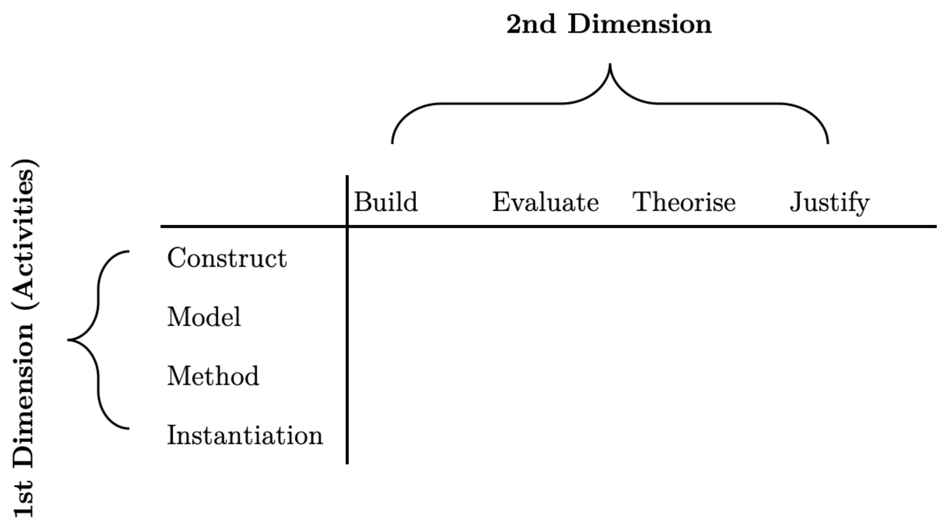


Figure 3-1: DS Framework
Framework by March and Smith (March and Smith, 1995) to distinguish between research activities and outputs.

Within the framework, the 1st Dimension refers to activities such as construct, model, method and instantiation. A *Construct* is defined as the vocabulary that is used to describe a problem domain. A *model* provides a set of rules, which expresses the relationships between constructs. Within DSR the model describes a problem with utility in mind. Utility ensures that a model does not only focus on capturing the real world but focus on capturing what is required to make it useful. A *method* refers to a sequence of steps that have to be performed to solve a problem, and an *instantiation* is the application of an artefact (a construct, model or a methods) within a novel environment.

With regards to the outputs (2nd dimension), a *build* demonstrates the feasibility to construct the artefact. Artefacts can be either constructs, models, methods or instantiations. The *evaluation* determines how well the artefact has met its requirements. Further outputs refer are named as theorise and justify; they refer to giving an explanation on how or why the artefacts perform within its specified environment (*theorise)* and using scientific evidence to *justify* the artefact's claims.

3.1.1. Artefact design and evaluation

Design Science Research methodology provides a structure for the creation and evaluation of novel artefacts. This structure essentially allows research to be followed and therefore be evaluated more easily by others (Peffers *et al.*, 2008).

Artefact creation ought to take utility into account. This means that the final artefact should improve the problem domain. Creating an artefact that solely solves a problem without addressing how it fits into the wider environment is suboptimal. The artefact "grows" together with increased understanding of the problem domain, as well as with changes to the problem domain. This means that the artefact develops incrementally, rather than being built all at once. The objectives are set in the beginning and the artefact is then delivered to meet these. The artefact then constantly evolves to meet its dynamic environment (Brooks, 1987).

Functionality is added as required until the final product has been created (March and Smith, 1995). Iterative design stems from software development, in which the product is continuously evolving in order to suite its changing environment.

Iterative and Incremental Design (IID) adds new functionality within each iteration whereas iterative design improves existing functionality within each iteration. IID is predominately used when the product is large in size and is complex in nature (Larman and Basili, 2003).

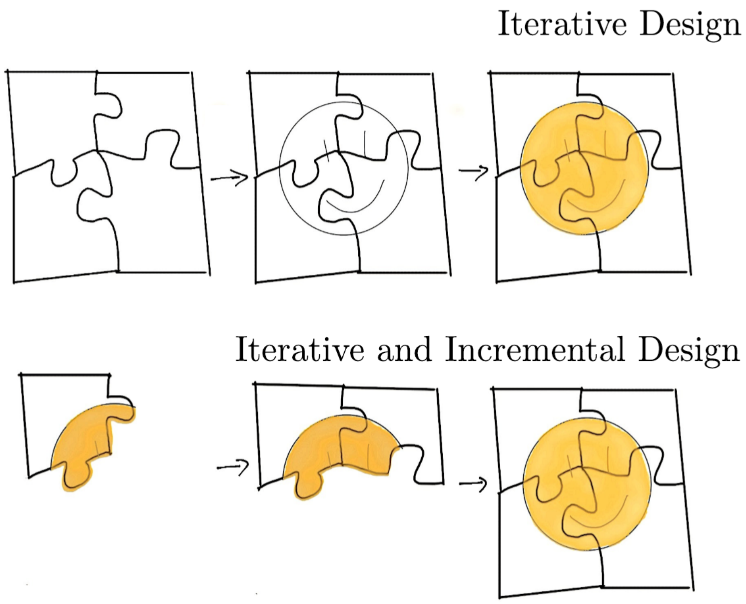


Figure 3-2: Iterative Design vs Iterative and Incremental Design
Visualises the difference between an iterative and an iterative and incremental design approach.

Evaluating artefacts is challenging because multiple factors of its performance must be considered within its problem domain. If only a subset of factors is considered, the problem may not ultimately be solved, or even worse, the artefact might have undesirable side effects (March and Smith, 1995). Evaluation does not only occur at the final step, but throughout the IID to allow to influence the design of the next iteration.

3.2. DSRM Process

In order for the research to be considered as a DSR it must follow certain rules and follow a defined sequence of activities as depicted in Figure 3-3.

The individual activities are followed sequentially, however the sequence could be entered at any of the possible research entry points. This allows the researcher to enter the research process at the beginning by observing a problem or even as late as the demonstration of an already existing artefact. This is then followed by an evaluation of the demonstration, based on which the either the solution objectives or the artefact design and development can be revisited. Finally, the research is communicated so that it can be assessed and learned from.

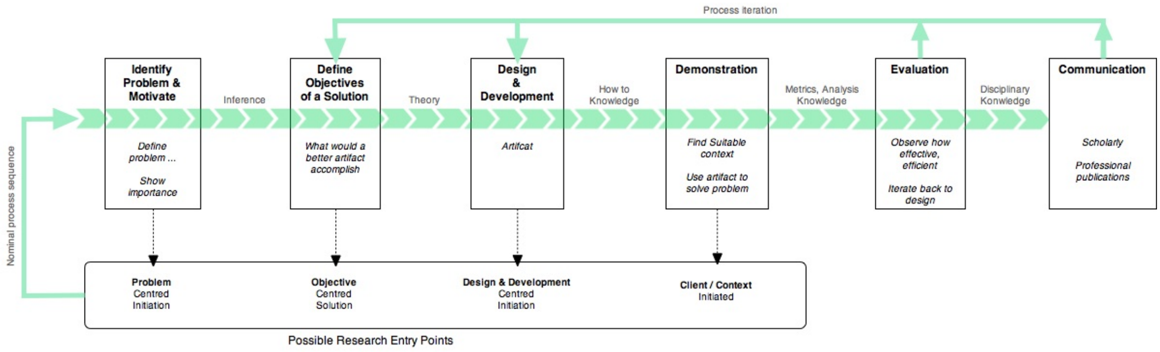


Figure 3-3: Design Science Research Methodology Process Model
DSR sequence outline based Peffers (Peffers *et al.*, 2008). The methodology is driven by the creation of an artefact which solves a problem in a new and innovative way. The artefact is then evaluated against how it solves predefined solution objectives. The artefact design itself can have multiple iterations, as part of the normal design process. Based on the artefact's evaluation outcome, a new cycle can be entered, either for further investigation the initial research problem, the solution objectives or the artefact itself.

DSRM activity description:

(1) the *problem identification and motivation* provide a definition of the problem and is intended to justify the relevance of a research artefact. This is intended to motivate the audience by highlighting the importance and applicability of the research.

(2) *Solution objective definition* - the solution-oriented objectives are drawn from the problem identification, showing how it would be an improvement of the current situation. This would also infer a more in-depth problem situation knowledge which would also state how the evaluation of the improvement should be measured, either be quantitative or qualitatively.

(3) *Artefact design and development* - Design and development of a solution artefact can take form as constructs, models, methods or instantiations.

(4) *Demonstration* - the demonstration activity analyses the proposed solution of the previously defined problem. This can be done in either conduction of a case study, conducting experiments or by any other adequate activity that demonstrates the

performance of the developed artefact. It is important to use a method of demonstration that shows understanding of the problem, the problem and research environment and the available resources.

(5) *Evaluation* - this activity determines how well the solution artefact solves the previously identified problem. Closely linked to the demonstration phase, this can use a variety of methods to validate the solutions performance, such as comparison to the original objectives set, quantitative performance measures or surveys.

(6) *Communication* - knowledge transfer to research and other problem field audience when suitable. Distribution of findings from the outline DSRM activities provides the basis for a formal report of the research findings, allows the research to be critically appraised by peers and colleagues and is thus an integral part of the research question in the wider context.

The applied methodology uses an updated version of Peffers framework (see Figure 3-3) by Ellis and Levy. This was selected as it appeared to be more pragmatic and therefore more applicable to the research setting (Ellis and Levy, 2010).

The DSR methodology concept outlined will be used as a general research umbrella to guide through the required steps to meet the aim and carry out the outlined objectives of this research. A more detailed overview of the research approach used here is provided in Figure 3-4 (Applied DSR Process), which demonstrates how the use of literature and subsequent iterative and incremental design is used in this research and aligned with the general DSRM concept.

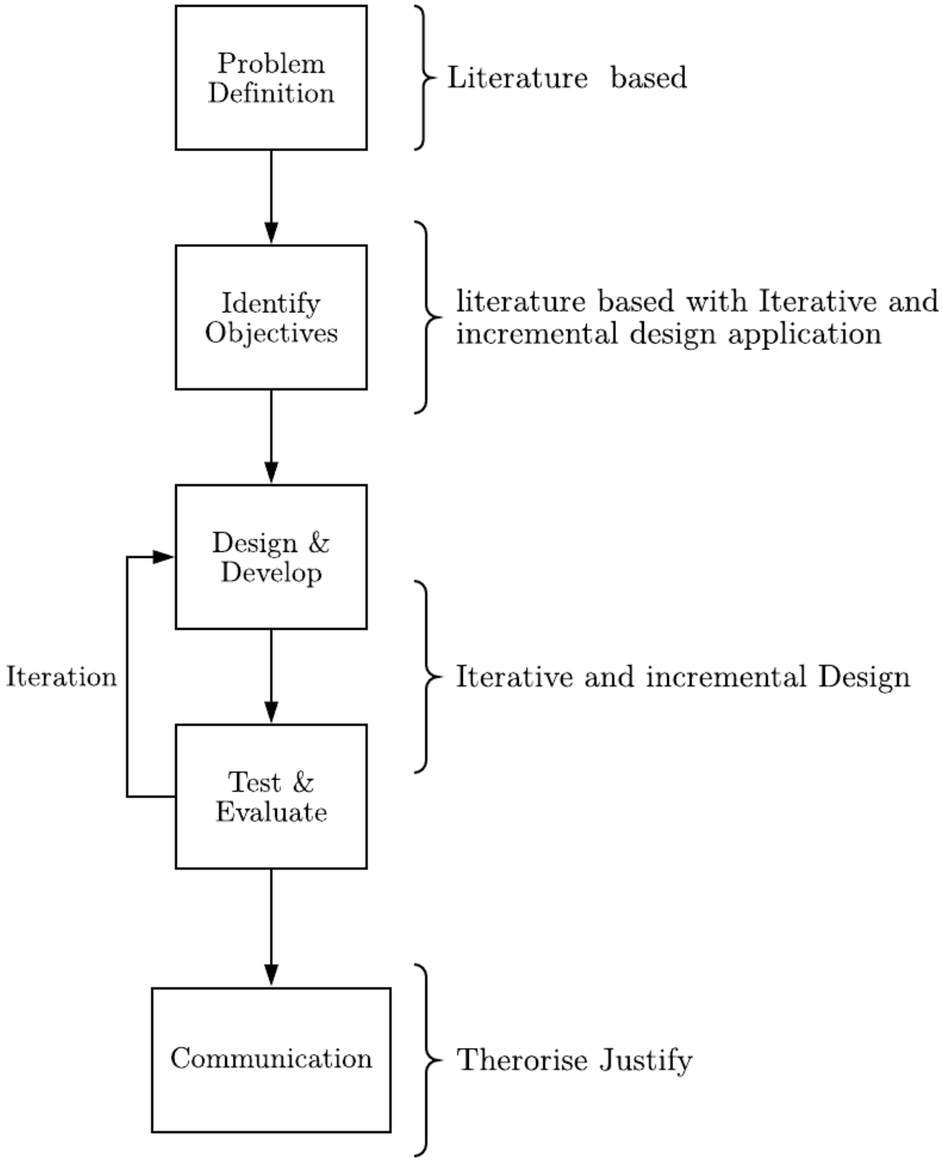


Figure 3-4: Applied DSR Process
Summary of the process that is commonly used

3.3. Research environment

The research was carried out in one of the largest premium cars manufactures in the world with over 16 vehicle production plants, spanning over seven countries. In addition to this, there are multiple engine, press and complete knock down production sites situated worldwide. Each plant has its own business unit with some departments which are centrally controlled and some locally. Highlighting the complexity caused by speaking different languages, educational levels and goals of each department.

The initial research motivation was based on understanding the vehicle production Electrical and Electronic systems test creation process. Preliminary investigation into organisational legacy data highlighted the complexity of a cross functional process, where stakeholders had problems interpreting existing process documentation. To address this problem, novel approaches to process modelling were explored. In 2002, the company started the project Systematic Process Improvement within the Technical (T) divisions (SPVT). The goal of this project was to define and improve the company's Electrical and Electronic (EE) Processes by following the Capability Maturity Model Integration (CMMI) process improvement approach. Within CMMI different process areas are defined which a company can choose from in order to improve its performance within an area of business, as discussed above. The current CMMI based process landscape does not include process monitoring and relies on lessons learned exercises to be carried out for identification of process improvements. In addition, the processes are not well communicated within the organisation or documented for easy use. This does not provide a solid foundation for structured process monitoring and necessary process improvements.

The research will be applied Production Planning and Validation process. This process is designed to provide the Plant with a vehicle EE test infrastructure, for both new vehicle projects and current series changes. It defines and creates the test content as well as the infrastructure within the plant that is needed to carry it out. The Test content is defined and created based on technical requirements of the entire vehicle. It is thus based on validation requirements of electrical connector connections, Electrical Control Unit programming and the initialisation of Electronic / Electrical components.

3.4. Application

This section provides an overview of the application of DSR to its research environment in two parts: the first describes about the overall process in relation to the chosen DSR methodology and the second refers to discussion of the research iterations.

3.4.1. DSR methodology application to research environment

This section provides an overview of “how” the research maps to the DSR process activities (see Figure 3-5).

An IID approach rather than a purely iterative one was chosen due to the complexity of the research problem. The research is segmented into five activities, namely Problem Definition, Objectives, Design, Evaluation and Communication. It has three iterations which are incremental allowing for each of the artefacts to be created separately before moving to on to the next one.

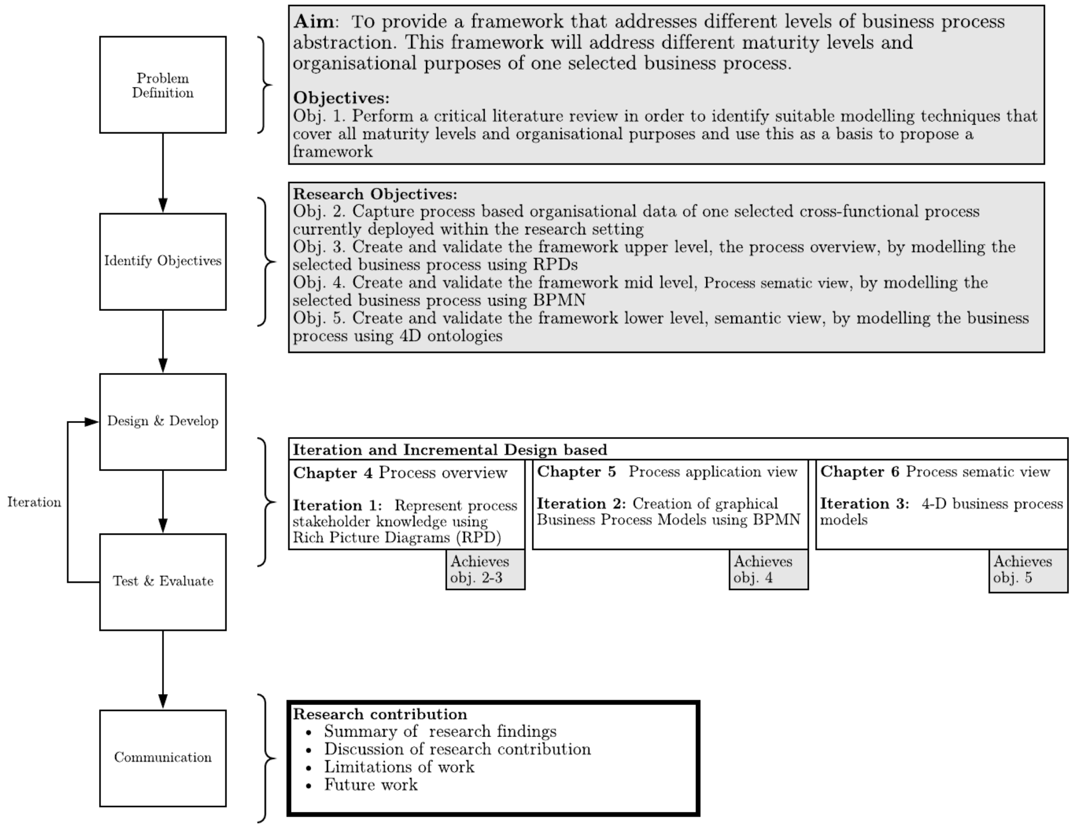


Figure 3-5: Applied DSR process
Provides an overview of the applied DSR methodology process and the five applied activities, to which the next chapters will correspond to

The problem definition is literature based; the subsequent objectives are based on the problem definition and correspond to individual artefacts. The main work which refers to the creation of the artefact design and evaluation activities consists of three iterations, discussed in detail later on. The final activity is to communicate, which includes to theorise and justify the research and its contribution to the wider field: the framework is discussed with focus on the outcomes of all iterations as well as discussion whether the set-out research aims were met.

3.4.2. Research iterations

The overarching research aim is to create a framework that depicts a business process and provides an understanding of the different levels of abstraction. Different modelling techniques are used to reflect that different methods might be more suited to different use cases. An iterative and incremental design is chosen to apply different modelling techniques to model a cross-functional business process for the creation of inline EE vehicle production tests. Table 3-1 summarises the three iterations, the design, technique and evaluation for each of them. The research problem is too complex to be approached in a purely iterative manner alone, therefore the three iterations use IID to allow to build each artefact in an incremental manner.

Iteration	Objective	Design	Technique	Evaluation
1	2. Capture process based organisational legacy data 1. Model business process overview using RPD	**Artefact** Process Overview **Type** Instantiation	Rich Picture Diagram	Semi-Structured Interviews
2	3. Model business process application view using BPMN	**Artefact** Process Model **Type** Instantiation	BPMN	Semi-Structured Interviews
3	4. Model business process sematic view 4D ontologies	**Artefact** Process Model **Type** Instantiation	BORO	Competency Questions
		Artefact Modelling method **Type** Method	Mixed (literature based)	Model completeness function

Table 3-1: Research Iterations

1st iteration, RPD: uses semi-structured interviews to create RPDs to build an overview of the business process. RPD itself is not a new method though its application as a purely business process overview and in this environment provides a new instantiation in addition RPD is then used as part of the overall framework.

2nd iteration, BPMN models: This iteration also uses an incremental desgin approach to build an artefact. Learning outcomes from the first iteration are used as process knowledge; additional semi-structured interviews are used to further model the process using an instantiation of established method.

3rd iteration, 4D Ontologies: this iteration uses the learning outcome from the previous iterations to further build process knowledge. In addition, learning outcomes from previous iterations provide high quality level of organisational data which in turn is used as a basis to create an instantiation of a 4D business process ontology. A combination of published approaches is used to propose a method that allows to not only build such an ontology but also to test and evaluate the final model to ensure ontological correctness.

3.5. Summary

This chapter provided an overview of Design Science Research methodology and the different activities within its process, as well as discussed, the details of an iterative incremental design. Additionally, the research environment – a multinational vehicle manufacturer – was introduced. In conclusion, the use of DSRM and IID suits the aims and objectives of this research for several reasons: firstly, DSR allows to bring together theory and practical application, which fits in with a real-world application. Secondly, this approach allows the artefacts to be created in an incremental manner, this is beneficial as the solution to the described problem is complex. Therefore, building each artefact allows to keep it manageable and be able to evaluate it. Furthermore, the use of the central aspects of the DSRM iterative process (design and evaluation) create a suitable environment to be applied during each iteration and artefact generation once the problem has been defined and objectives have been set out. And finally, DSRM offers a structured approach that can be followed in critically appraised in future to allow future researchers to learn from this work. The following three chapters will lay out the iterations for this research in detail.

Chapter 4. Iteration One: Development of a Processes Overview

4.1. Chapter Overview

This chapter discusses the application of Rich Picture Diagrams (RPD) as a technique to model the Business Process overview for the creation of Electronic and Electrical (EE) vehicle production inline tests. It is the first iteration of three, with the next two described in the following chapters (see Table 4-1).

The overall aim is to propose a framework that allows for the creation of different levels of process abstraction within the organisation, this iteration provides the process overview and gathers the organisational legacy data for the following chapters.

The research problem and objectives are introduced with a focus on the aspects covered within this iteration. A description of the research environment, its overall process description and roles is included before an in-depth discussion of artefact design and build (for a detailed discussion of the selection of modelling technique and rationale see Chapter 3 methodology). This chapter concludes with an evaluation on how the artefacts meets the objectives as well as a discussion of the limitations and encountered difficulties during the artefact creation process.

Iteration	Objective	Design	Technique	Evaluation
1	2. Capture process based organisational legacy data 1. Model business process overview using RPD	**Artefact** Process Overview **Type** Instantiation	Rich Picture Diagram	Semi-Structured Interviews
2	3. Model business process application view using BPMN	**Artefact** Process Model **Type** Instantiation	BPMN	Semi-Structured Interviews
3	4. Model business process sematic view 4D ontologies	**Artefact** Process Model **Type** Instantiation	BORO	Competency Questions
		Artefact Modelling method **Type** Method	Mixed (literature based)	Model completeness function

Table 4-1: Research iterations

Problem and objectives

The overarching research aim is to develop a framework that can aid to represent and understand different levels of business process abstraction within an organisation. This (first) iteration focusses on the creation of an overview of the EE vehicle production in-line tests process using RPD. In other words, this iteration aims to create an instantiation by exploring the feasibility of RPD application to the outlined research environment. The artefact aims to provide the process overview and provide the upper layer of the proposed multilevel framework.

This iteration addresses objectives 2 and 3 (see Figure 4-1). Objective 2 refers to capturing process based organisational data for one selected cross-functional process currently deployed within the research setting whilst objective 3 refers to the creation and validation of the framework upper level, the process overview, by modelling the selected business process using Rich Picture Diagrams.

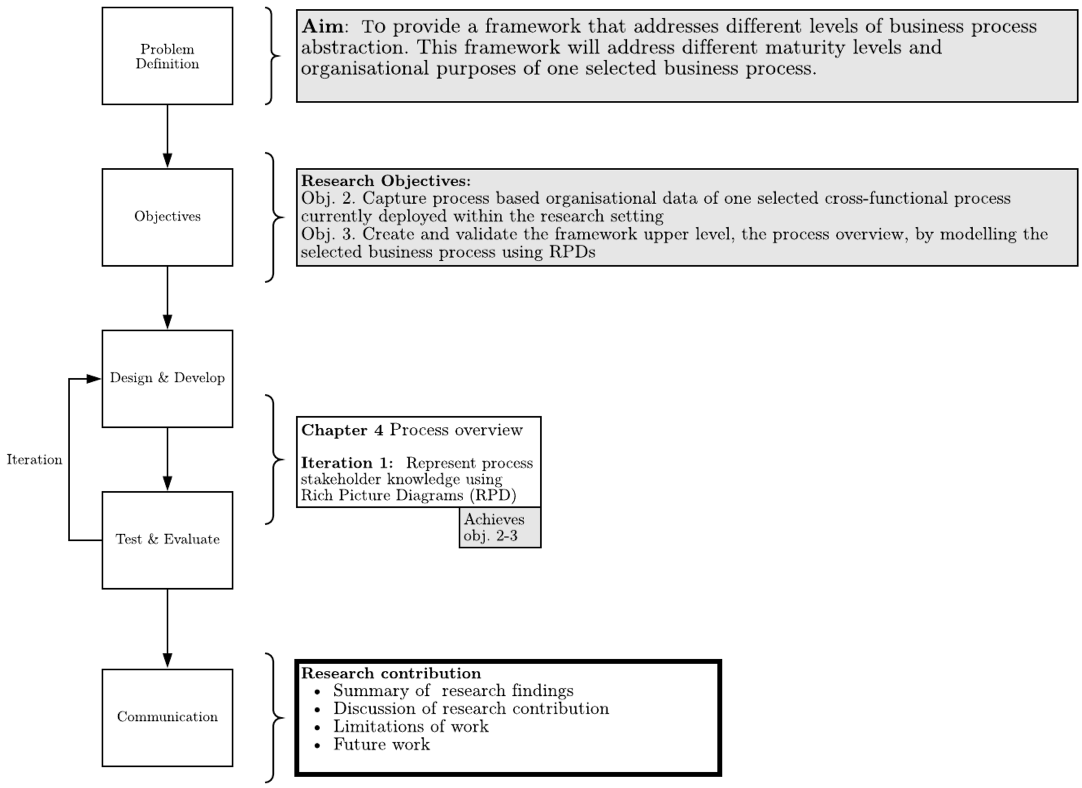


Figure 4-1: Applied DSR process
Provides an overview of the applied DSR methodology process and the five applied activities, to which the next chapters will correspond to.

4.2. Research environment: roles and process description

4.2.1. Roles (Job descriptions)

To help understand the organisation's roles, Table 4-2 provides a list with a brief description for each. It should be noted that a *detailed* understanding of each role is not required to fully understand the described process, but a basic understanding might be beneficial for reviewing the process models.

Job Role	Abbr.	Description
Arbeitskreis	AK	is a circle, which is comprised of representatives from all EE planning team leaders from all plants and central functions. The department head chairs it. An AK member refers to one of the team leaders making up the AK.
Assembly Leader	AL	The AS is in charge of all of the plant vehicle assembly. This does not include Body and white (vehicle body assembly) or vehicle paint.
Function Specialist	FS	The FS designs and implements technical solution for testing vehicle functions within a production process. This role interacts both with the research and development department and the PS in order to provide an optimum solution for a production process.
Process Integrator	PI	The Process Integrator for a project manages the planning and implementation activities for both PEP (Produktentstehungsprozess, the process of product development) and/or SBWE (Serienbetreuung/Weiterentwicklung, series management and improvements). The goal is to have an efficient integration using cross-functional processes as foundation and building blocks, and considering internal and external standards and plant specific information. The main responsibilities lie within project risk, requirements management and process integration. Later on, the process commissioning is handed over to the plant for local implementation to the PI-Plant.
Process Leader	PL	the PL is responsible for manpower and quality management within his production line area. The production line is divided into eleven Process Auxiliary Units (APUs).
Process Specialist	PS	the PS is the expert for an overall test sequence / area (the so-called Pruefplatz), which consists of a single test. Acting as interface between several roles within the project and the plant the PS plans, implements and optimizes the test system using the BMW version of Toyota Production Principles (TPS), namely its own Value added Production System (VPS). Each test system and its PS are part of a groupwide specialist team (the so-called Fachteam), which provides best practice and support during problem resolution.
Quality Specialist	QSP	The QSP feeds back analysis results as a result of test system defects that have occurred during the vehicle prototype build, i.e. the validation phase. This role also verifies that the proposed solution to a defect is valid.
Section Leader	SL	There are three sections within vehicle Assembly, which were grouped by multiple APU areas. Section 1 vehicle subassembly, section 2 vehicle full assembly and section 3 vehicle validation and initialization. Each section has a SL who is responsible for manpower and quality management.
Team Coordinator	TC	Each Process Auxiliary Unit (APU) is subdivided into smaller areas. The TC coordinated these areas' manpower and quality issues. The job role reports to the PL.

Table 4-2: Role Descriptions
This table lists and describes all relevant roles within the business process which was used for this research.

4.2.2. Process description

This section describes the selected process. This particular process was chosen for several reasons: it is a process that is well established within the company, however complex and cross-functional at the same time; in addition, the involved stakeholders and the department were interested in engaging with and supporting this research. Within the process landscape, there were multiple possible candidates and the final choice of process was made in agreement with the department and process owner.

The initial step is for the Aktionskreis (AK) to appoint usually one Process Integrator (PI) for the project (a new vehicle within the product line up). The PI then initiates the 'Project Kick Off', with focus on an initial 'Project Implementation Plan' and the naming of the 'Project Team', made up of several experts in their respective fields (e.g.

Functional Specialist (FS), Process Specialist (PS), the Quality Specialist (QS) and the Methodiker (M)).

The PI gathers and evaluates information; this can be either best practice modules or other technical documentation relevant to the project. For PEP projects this information is processed by the project team and is then used to create the TEQ-Leitfaden. The TEQ-Leitfaden is the guiding document for meetings with the engineering counterpart to discuss the technical details required for testing. SB/WE projects use similar documents depending on the content and complexity of changes.

The Project Team then creates a Requirements Catalogue based on the TEQ-Leitfaden, highlighting relevant factors for testing and commissioning the processes. In the next steps, a Commissioning schedule is decided upon, considering both the Requirements Catalogue and a so-called BUZ Factor, which takes the financial effect of the technical changes to the project into account. This now provides a detailed view of the project phases, including testing and timing schedules. The Commissioning Schedule is intended to provide information on what and when processes are being tested; in addition, it incorporates the plant's integration plan and provides an overview of the maturity of the project processes.

A description of the core processes is then composed by the PS and published as a TVG (Teilvorgang). The TVG partially describes the overall process, giving documentation of one step of the process. The description of such a process step can consist of documentation of the test, its ergonomics and timing. The TVG provides the foundation for the testing knowledge, the actual technical solution.

This is then tested and validated, and when the process step has reached its desired maturity it is integrated into the PPG (Production Process Group), with addition of user interactions, thus setting up the full test sequence for the PPL (Pruefplatz). Test and validation activities are then carried out on the full production process for this PPG.

The output of this test and validation is documented in the Approval Protocol, which provides a list of open topics and the overall maturity of the production processes that are being handed over to the plant. Once the handover has occurred, the PI-Plant will take over the management task of the implementation in the local plant. Tailoring of the processes to plant specific requirements should be reported back to the Project Team. Any problem analysis of the test knowledge within the plant should be either carried out by the Functional or Quality specialist or put in into QMS (Quality Management System) for problem resolution. Problem resolution is then handled centrally, e.g. by the Process or Function owner. Once the desired process maturity is reached, the process is entirely handed over to the plant.

Appendix A (Job descriptions and business process documentation) includes a process description in the format of an Excel sheet as is the current practice.

4.3. Artefact design

4.3.1. Rich Picture Diagrams as a modelling technique

Rich Picture Diagrams (RPD) have their origin in the Soft System Methodology as discussed in more detail in Chapter 3 (Methodology). Their original instantiation focussed on capturing a more complex situation using a simpler representation – this allowed easy understanding within an organisational setting (Siau and Wang, 2007). The underlying idea is that the modeller can create a 'picture' of the current situation in form of a diagram – in whatever form is appropriate for that situation – there is therefore no formal syntax and the modeller is free to choose which shape the RPD takes. Although originally designed to particularly unpick socio-political interactions with an organisational system, the application of RPD in this research focusses on activities, their inputs and outputs as well as who carries them and their role in the process. In addition, this research makes use of its ease of application, without a prescriptive syntax:

semi-structured interviews are used to create diagrams and build on these iteratively until the final state is reached, each time using previously updated RPDs to guide the interviews.

Peter Checkland applied this method as it particularly suited his study of organisational environments: it allowed to bring an organisation almost instantaneously to the same level of understanding based on the current level of RPD provided. This allowed a discussion of the RPD within the organisation and changes could be simply drawn onto the diagram; this process then continued until no more changes were identified and no adjustments of RPD required (Checkland, 2000)

4.3.2. Design approach

The design approach for this artefact creation aimed to use interviews to build a series of Rich Picture Diagrams to investigate organisational legacy data using a selection of process stakeholders. The RPDs were both used as a tool to structure the interviews but were also themselves (after multiple iterations) the final artefact.

RPDs have been used within organisational research as has been discussed above, however their use in business process research is a fairly novel one (see Chapter 2 Literature Review). There is no depth of literature in using RPDs in process descriptions. The inherent absence of strict formal syntax was considered a benefit in bringing this technique to the organisational setting. It therefore did not require the stakeholders to adapt to a new syntax and to discuss their understanding freely.

Semi-structured interviews (see appendix B. Documentation of interviews) were conducted at the stakeholders' workplace and were used to build RPD iteratively. The iterations were used to refine the RPD, as well as the modeller's and stakeholders' understanding of the process and its representation. Use of the RPD as a discussion tool allowed to identify pre-existing problems and difficulties associated with previously used process descriptions. This approach mirrored Checkland's SSM which used RPD as a tool to gather the perceived real-world view as an easy way of conveying it to others and bring everyone on to the same level of understanding. The underlying idea was that by creating a picture, it will help to point where more information is required (Monk and Howard, 1998). This implies that each interview is used not only for information gathering but can also be used to validate the progress of the RPD model at this stage. It is important to review the created RPD with the stakeholders to ensure that their views have been correctly captured. This process continues until the modeller and/or the stakeholders see no need for any further changes, or no new information is obtained (see Figure 4-2).

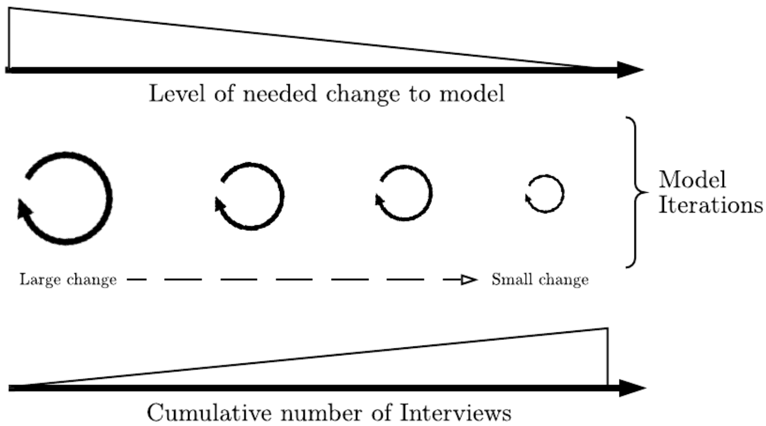


Figure 4-2: Design approach

Figure 4-2 shows how with cumulative number of interviews, smaller levels of adjustments to the RPD were deemed necessary. The assessment of completeness of the RPD is based on utility, which in this case means engagement with stakeholders is used to determine whether the RPD in that current form can be considered useful.

The RPD were initially hand drawn and adjustments to the RPDs during the interviews were captured in handwriting as well. The software Curio (Zengobi inc., 2013) was then used to create the updated RPD and the final artefact.

4.4. Development using a Rich Picture Diagram as a process overview

The initial investigation gathered and interpreted organisational data and presented it graphically in form of an RPD. Initially, a cycle of semi-structured interviews was held with the purpose of understanding the organisational complexity. The creation of the RPD was an iterative process, primarily looking at the interaction and local knowledge of the organisation. At the earliest stage, it was identified that the process needed to be discussed from two angles: the planning process vs the vehicle production process. It was only after both were addressed individually to understand their (individual) complexity, that they were combined. The organisational legacy data such as process documentation and role descriptions were only included in the later stages. This is reflected by RPDs initially focussing on production or planning before later stages provide a combined overview with focus on the planning process.

4.4.1. Description of use of semi-structured interviews for artefact creation

Initially, ten interviews were conducted (for characteristics and further information about interviewees, see Table 4-3). The interviews were semi-structured with the current version of the RPD used to replace a question-based topic guide. Although no formal topic guide was used, the questions asked were similar from interview to interview and included the following:

- What do you think of the understanding of the process as per the RPD?
- What would you change?
- How do you fit in?
- Who else do you think I should contact?

Any follow up questions were based around the annotations and changes to the RPD.

Topic	Job Title	Dept.	Length (min)	interview	Key Aspects	Diagram
Process Overview	PI (OX plant) L3	TI-53-U	30	1	Initial meeting - production overview.	Production
Process Overview	FS (plant)	TI-53-U	30	2	Initial meeting - roles, responsibilities and interactions.	Planning
Process Overview	PI (OX plant) L3	TI-53-U	30	3	Roles, responsibilities and interactions.	Planning
Process Overview	PQA (OX plant)	TO-40	15	4	Defining how the production process out-put is measured.	Production
Process Overview	AK member (OX plant)	TI-53-U	15	5	Addition of process sheet process, flow for EE planning process.	Combined
Process Overview	FS (OX plant)	TI-53-U	30	6	Review of plant roles within newly created process diagram.	Combined
Process Overview	PS (OX plant)	TI-53-U	20	7	Review of PI process, activities and when they are triggered.	Combined
Process Overview	PS (OX plant)	TI-53-U	30	8	Revision of RPD with view of plant roles.	Combined
Process Overview	PI (central) LU	TI-534	30	9	Revision of RPD with view of non local roles and activities.	Combined
Process Overview	PSP (OX plant) LU	TO-513	45	10	interactions with PSP role was correctly interpreted.	Combined

Table 4-3: Table of Interviews 1st Iteration
For each interview, the interviewee job title, department and length of interview is listed. Key aspects of the interview are also included as well as explaining which aspects of RPD creation the interview was involved in.

During the interviews a printed version of the existing RPD was simply drawn onto to either correct or to expand on it. This not only provided a platform for structuring the information gathering, but also instantaneously sharing it with the interviewees. This technique offered two benefits, (1) the interviews thoughts were captured and displayed and (2) for each new interview it could easily be used to provide an overall view of the current process. The RPD was especially useful in this context as it grew in parallel with the researcher's and interviewees' understanding of the process. The interactive nature and dynamic ability to use the RPD as a mean of communication and discussion was received positively within the organisation.

Figure 4-3 shows an overview how individual RPDs and annotations from interviews were used to generate updated RPD (high resolution scans of all RPDs and annotations can be seen in the Appendix). This shows an example how the interview with a process integrator (top) was used to create an RPD by the interviewer. This RPD was then in turn used as a basis for discussion with a function specialist. Annotations and changes made during this interview were then used to update and correct the developing RPD. Overall, it was perceived as providing an easily understandable picture of the process, activities and its stakeholders.

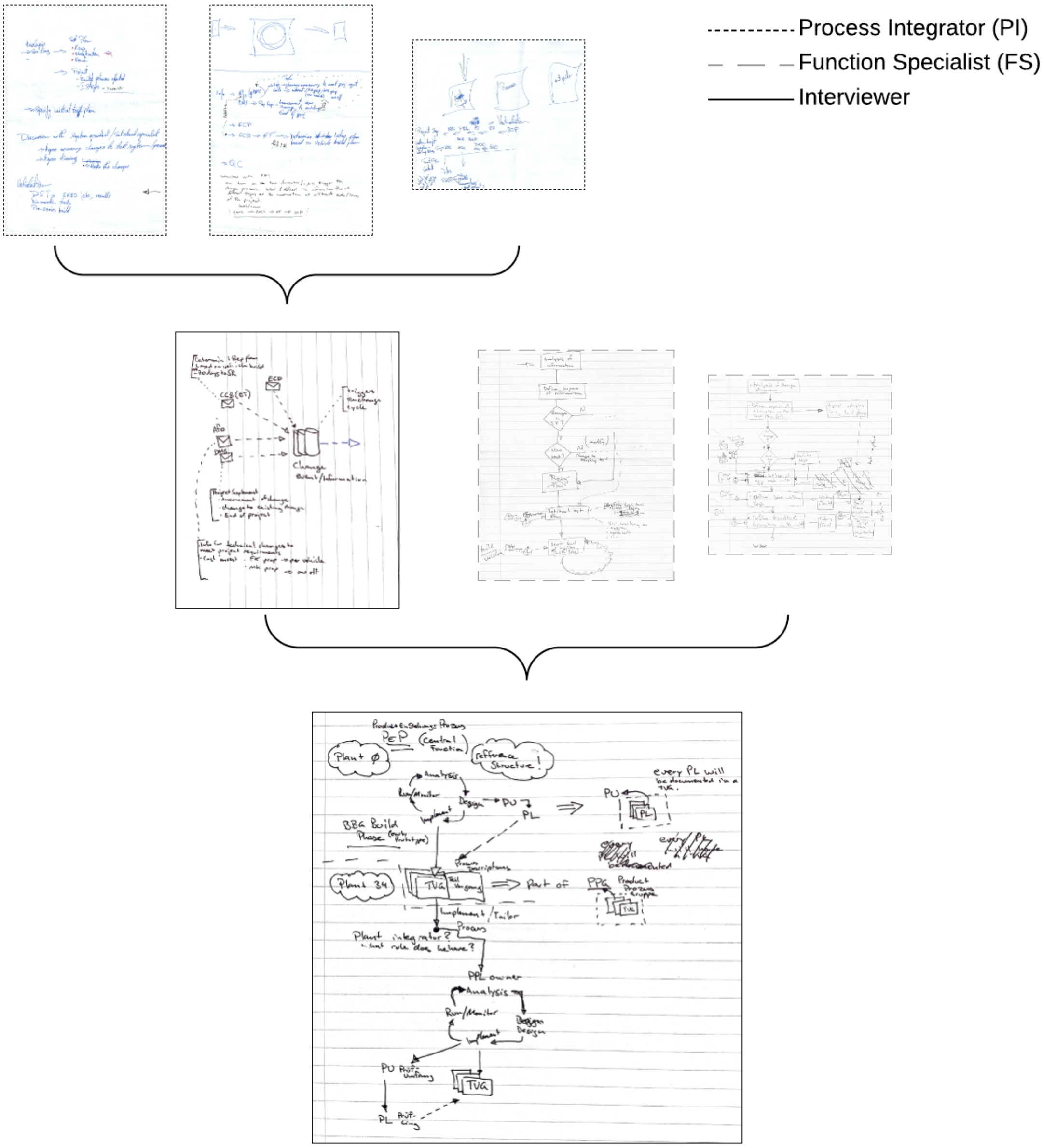


Figure 4-3: RPD planning process view creation.
Top: interview with process integrator notes and developing RPD. Middle: left – RPD in progress based on interviews and RPD with PI. This was used to inform and discuss the planning process with a function specialist (middle and right). The combination of the evolving RPD and FS interview was then used to re-work the RPD and create an updated version for further interviews (bottom)

4.4.2. Rich Picture Diagram creation

The creation of the RPD was an iterative process which primarily looked at the interaction and local knowledge of the organisation. During the initial planning of the interviews as well as during the first interviews, it was identified that the model needed to be broken down into two areas: the process planning and production process itself. Therefore, at the earlier stages, other organisational legacy data such as process and role descriptions were not included. One of the first created versions of RPD (see Figure 4-5) depicts a rather basic understanding of those interactions between departments. The iterative research progress then allowed to use this as a basis to clarify interactions and build on to incorporate more information, based mainly on the information from the final six interviews.

The contrast of Figure 4-4 top panel and lower panel allows to understand how iterative interviews based on the RPD lead to the change in the researcher's understanding with each interview. The RPDs were updated in iterative steps. Each step followed the same sequence: An interview was held in which the RPD was presented as the researcher's current view of the process. The researcher explained the RPD and the interviewee was asked to express their opinion on this view. The interview was concluded when the interviewee and researcher agreed to have the same understanding of the RPD at this stage. Changes were made to the RPD to reflect and display the discussed points and an updated version of the RPD was then used as the basis for the next interview. There was no routine follow up interviews with each individual interviewee. However, if follow up interviews with the same stakeholder were arranged, this opportunity was used to verify and improve the RPD.

Table 4-4 summarises the characteristics of interviewees. The initial four interviews were held with identified process stakeholders, which lasted between 15 to 30 minutes in order to create the RPD in Figure 4-7. Those four interviews allowed to create initial RPDs for production and planning separately, whilst the subsequent six interviews were used to combine production and planning in one RPD and build from there. The RPD were purely based on the plants' view of the process. The interviews were not audio-recorded, as the use of RPD and the discussion surrounding the pictures would not have been captured by recording the conversation only. This is a possible limitation of the study.

The RPD as a way to represent the process and offer a discussion point was well received in the interviews; it provided the process stakeholders with a complete process overview which allowed them to see how their activities fit into the overall picture:

> *"Yes, it is excellent, and it will be useful to communicate with the organization with this sort of Rich Picture Diagrams"* (Subject FPS-P2 / Functional and Process Specialist).

4.4.3. Creation of planning and production RPDs

Initially, semi-structured interviews were used to create RPDs for both the production and process planning aspects of the process separately. Identified employees were invited to attend interviews: three separate employees were interviewed (see Table 4-4), one of them was invited for a second interview to enhance the created RPD model. The first two interviews and the subsequently created RPD focused on creating an initial overview of how the department (EE Process Planning department) interacts with the vehicle production process and secondly on the process planning process (see Figure 4-6)

Topic	Job Title	Dept.	Length (min)	Interview	Key Aspects	Diagram
Process Overview	PI (OX plant) L3	TI-53-U	30	1	Initial meeting - production overview.	Production
Process Overview	FS (plant)	TI-53-U	30	2	Initial meeting - roles, responsibilities and interactions.	Planning
Process Overview	PI (OX plant) L3	TI-53-U	30	3	Roles, responsibilities and interactions.	Planning
Process Overview	PQA (OX plant)	TO-40	15	4	Defining how the production process out-put is measured.	Production

Table 4-4: Interviews for production and Planning RPDs

Some interesting learning points were identified during those first few interviews, and as they informed the future modelling approach and technique, they are discussed in more detail here:

Method used to capture RPD during interview

The plant Process Integrator (PI) was chosen for the first interview due to their position and the role they occupied, giving them a strong overall process knowledge. As the first interview did not have an RPD to start with, the interviewee guided the development of a basic RPD using their overall process knowledge and experience.

The concurrent recording using software during this interview was identified as too tedious and time consuming, therefore sketches ("pen and paper") were used for the following interviews to allow a free discussion and conversation. This also allowed to respect the limited time the stakeholders had available. This approach was continued in the first few interviews. In future interviews, once electronically modelled RPD already existed it was used in both a paper form for discussion and annotation as well as an electronic form for smaller adjustments. The second interview was carried out with one of the plants Functional Specialist (FS) – who creates the electronic vehicle tests. They were selected based on a recommendation arising from the first interview and an identified need to be able to discuss aspects of the planning process in contrast to production. The RPD created during and after the first interview was presented and this time pen and paper were used throughout which allowed for a better interaction with the stakeholder.

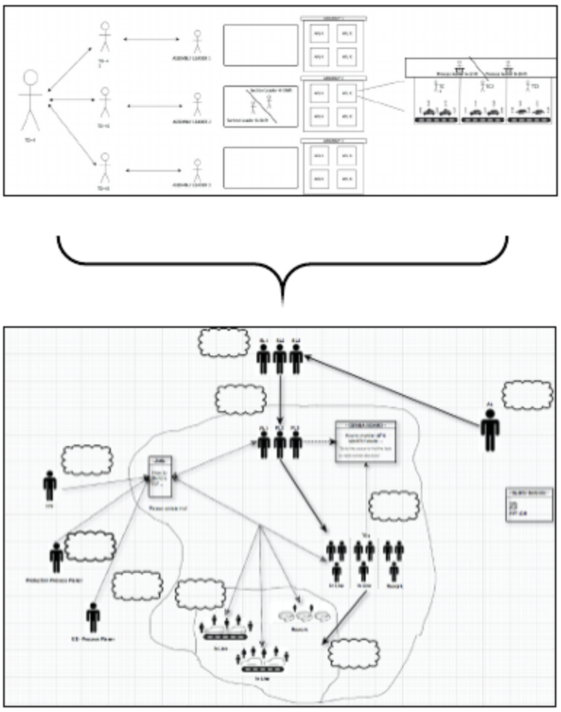


Figure 4-4: RPD production process view creation
Example of RPD diagrams, highlighting the change between iterations.

Use of interviews to clarify terminology used within RPD

An example from the third interview shows how iterative interviews helped to improve understanding by identifying mistakes presented on RPD. The third interviewer was able to clarify some of the terminology used: ZMD (Central Production Database), which had been incorrectly used as a term to describe processes. In reality, ZMD was only a central database that stored PPGs (Process groupings) and actual TVGs (Process Activities). TVGs should have only been used to assign time to process activities that require someone to physically do something, such as manual interactions or simply wait for something. This highlighted that clarification of terminology is important early on in the modelling process, and that using several interviewees can allow to identify misconceptions.

Use of RPD elements such as pictograms (clouds)

Initially one of the techniques used in the RPD was inclusion of ‘clouds’ to allow to add comments or thoughts which resemble impressions of a job role. These were initially left blank or were intended to use simple sentences – however this concept was abandoned after the initial interviews as it felt it was better to avoid potentially controversial impressions of individual roles (see Figure 4-5). In addition, it felt that it would take away from the focus on capturing process flows and interactions. However, in line with Checkland’s use of RPD to capture socio-political interactions it is possible to expand RPD with such “cloud” annotations – if deemed relevant for the research or diagram purpose.

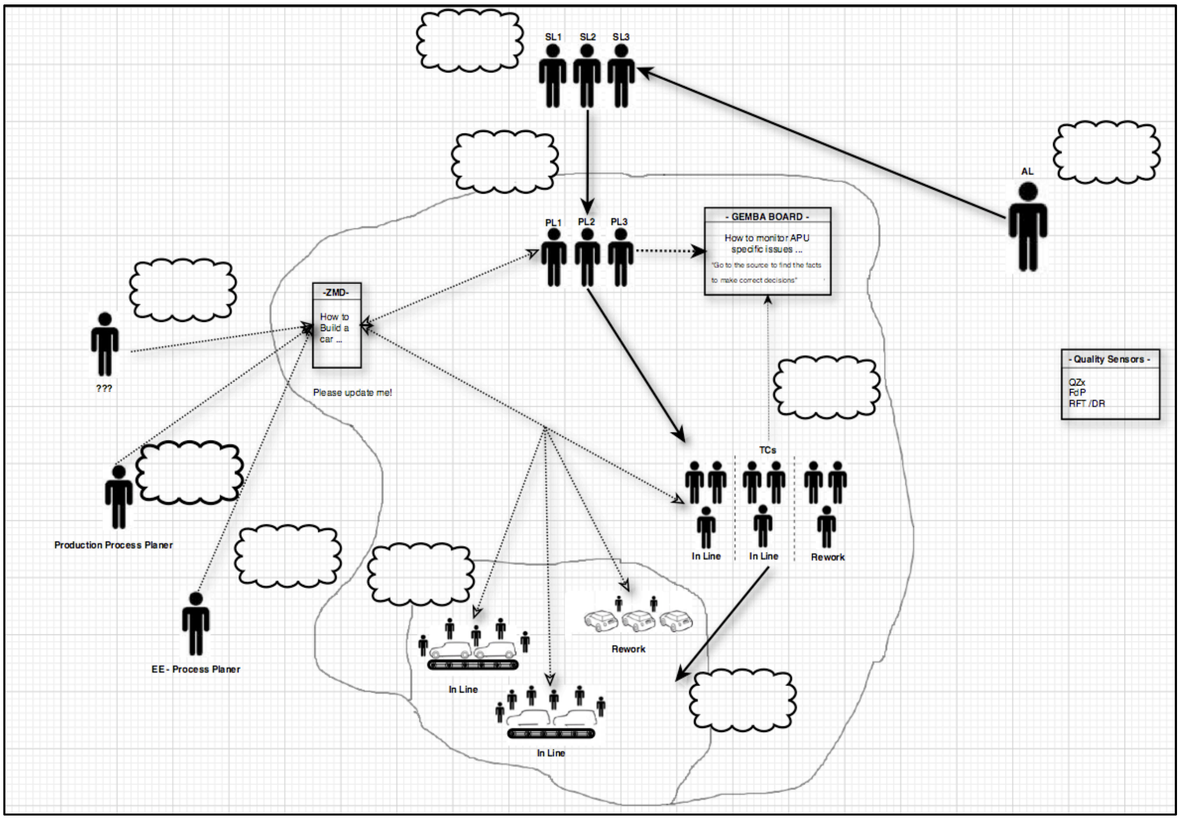


Figure 4-5: Production RPD example
This RPD initially focuses on the interactions between production and EE process planning, the RPD in later iterations becomes more accurate.

4.4.4. Combined RPDs

After completion of the initial interviews to create RDPs of planning and production, it was possible to identify an overlap and to start creating a combined RPD. The researcher then created a first version of a combined RPD of planning and production. This was then used to guide the questions during six interviews subsequently conducted to create the final RPD (see Table 4-5). The interviews ranged between 15 and 45 min in duration and were mainly used to improve the process planning aspect of the RPD; although each new information relating to the production process was also incorporated.

Topic	Job Title	Dept.	Length (min)	Interview	Key Aspects	Diagram
Process Overview	AK member (OX plant)	TI-53-U	15	5	Addition of process sheet process, flow for EE planning process.	Combined
Process Overview	FS (OX plant)	TI-53-U	30	6	Review of plant roles within newly created process diagram.	Combined
Process Overview	PS (OX plant)	TI-53-U	20	7	Review of PI process, activities and when they are triggered.	Combined
Process Overview	PS (OX plant)	TI-53-U	30	8	Revision of RPD with view of plant roles.	Combined
Process Overview	PI (central) LU	TI-534	30	9	Revision of RPD with view of non local roles and activities.	Combined
Process Overview	PSP (OX plant)	TO-513	45	10	interactions with PSP role was correctly interpreted.	Combined

Table 4-5: Interviews for combined RPDs

After interviewing the AK (plant) member, the team lead for the EE process planning team, additional organisational legacy data in form of process and role description was made available. This information was initially difficult to interpret even by involved stakeholders mainly due to the format and use of language in which it had been captured. It was provided in spreadsheets using textual descriptions (see Figure 4-6). The following two quotes from the process descriptions demonstrate examples of used descriptions which were difficult to interpret – not only by the research but also by subsequent interviewed stakeholders carrying out those processes.

> "*After successful approval with sufficient process maturity the course of commissioning is handed over to (incl. HN)*" (see appendix A)

or

> *"This leads to an evaluation of the BUZ factors (incl. TVG-estimated values on the basis of reference TVGs or actual values of comparable projects"* (see appendix A)

It was not until the penultimate interview, an interview with the central PI for the new product line (LU), when the terminology, the process activities and their sequence were explained in detail and therefore understood well enough to add them to the RPD.

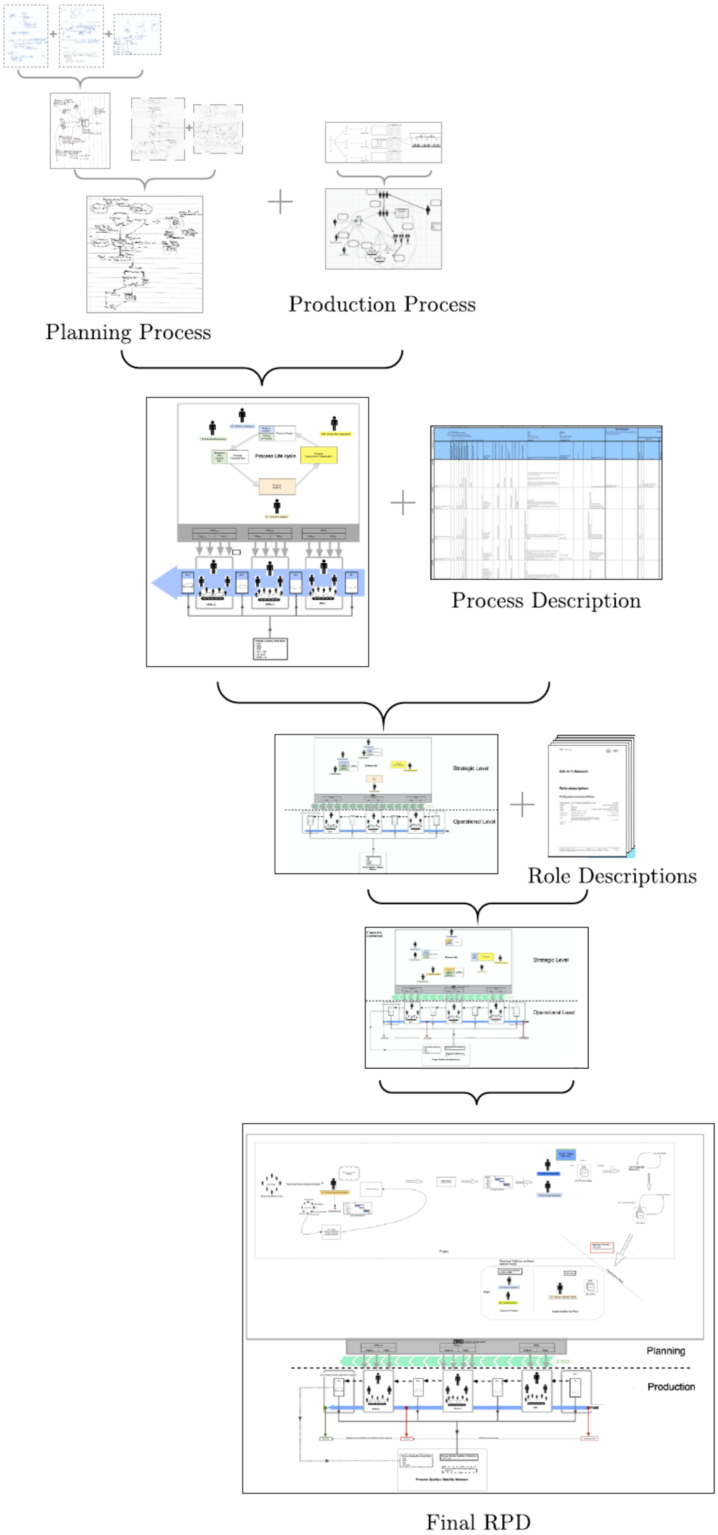


Figure 4-6: RPD combined process view creation
Overview how RPDs created during all ten interviews were used to initial create separate planning and production RPDs and then subsequent interviews allowed to create a combined RPD after including organizational legacy information

Process step ID	Process step	Typical duration (PT in h)	Completion venue (plant/head	Predecessor process ID	Successor process ID	Start as per Synchroplan	End as per Synchroplan	Start criteria (event / time)	End criteria (event / time)	from	Input delivery (from role / system)	Management (role / department)
02918913	Agree and document necessities for E/E testing and commissioning	n. rel.		2918912	2918914	Bestätigung Zielrahmen	[illegible] Sicherheit			T-E/E-Prozessintegrator Projekt,	Documentation of technical information (PUMA, KMG, development information, etc.)	T-E/E-Prozessintegrator Projekt
02918914	Influences on product: gather, collect and generate E/E requirements for testing and commissioning	n. rel.		2918913	2918915	Bestätigung Zielrahmen	[illegible] Sicherheit			T-E/E-Prozessintegrator Projekt	Description of components for commissioning and testing (e.g. filled-in TEQ-Leitfaden or information reg. the commissioning schedule (Inbetriebnameplan)	T-E/E-Prozessintegrator Projekt
02918915	Conduct economical project evaluation	n. rel.		2918914	2918916	Bestätigung Zielrahmen	Bestätigung Markteinführung & Prozess-Sicherheit			T-E/E-Prozessintegrator Projekt	Evaluation premises project, filled-in TEQ-Leitfaden, commissioning schedule as far as available, status requirements management	T-E/E-Prozessintegrator Projekt

Process step ID	Decision (role / department)	Implementation (role / department)	Information to (role / department)	Support (role / department)	Activity description (input / method / frequency / system / output)	Binding documents (specifications, directives, etc.)	Binding tools	to	Output delivery (to role / system)	Milestones in Synchroplan	Interface to other PAs
02918913		Funktionsspezialist, Prozessspezialist, Q-Spezialist, Methodiker		Entwicklung (z.B. Modulrunden und SE-Teams), Fachteam Prozessintegration	Clarification of responsible parties for the implementation by T-E/E process integrator. Clarification, definition and documentation of the component specific and functions specific requirements reg. the necessities for testing and implementation (e.g. TEQ-talks, also informal contacts, developer talks) in consideration of E/E-Prozessbaukästen. Deduction of process effects incl. SBM.	PEP: TEQ-Leitfaden SB/WE: depending on project content.		T-E/E-Prozessintegrator	Description of components for commissioning and testing (e.g. filled-in TEQ-Leitfaden or information reg. the commissioning schedule(Inbetriebnameplan)		
02918914		T-E/E-Prozessintegrator Projekt		Entwicklung (z.B. Modulrunden und SE-Teams), Fachteam Prozessintegration	The requirements are phrased and documented (e.g. in ZAK/DOORS and Lastenheften) and monitored afterwards (e.g. LH-Reviews under the direction of the T-E/E integrator). Generic requirements (a.o. E/E-Prozessbaukästen) are implemented via T-E/E requirements management.			T-E/E- Integrator oder Projekt	requirements catalogue (Anfordungskatalog)	**at Zielvereinbarung PL-Derivat:** Anforderungskatalog	3.3 "Conduct T-E/E requirements management"
02918915	AK E/E-Prozessplanung	T-E/E-Prozessintegrator Projekt		Funktionsspezialist, Prozessspezialist	The process effects, that result from the technical contents (incl. change requests via gAMS) of the project, are evaluated economically and detailed iteratively. This leads to an evaluation of the BUZ factors (incl. TVG-estimated values on the basis of reference TVGs or actual values of comparable projects). set up technical requirements (TA).	PEP: Template Resource planning and evaluation SB/WE: plant-specific documents	PEP: AOL, MIP - SB/WE: no binding tool	Fachprojektleiter, E/E-Integrator	BUZ factors	**at Zielvereinbarung PL-Derivat:** coordinated BUZ factors	10.5 "Plan and procure T-E/E equipment and services", 10.2 "Conduct economical project evaluation" (only for PEP, for SB/WE plant-individual process)

Table 4-6: Process documentation example

Sample subprocesses form the EE Process Planning process for the creation of vehicle production inline test document.

The interviews preceding this clarification were therefore associated with some difficulty: for example, the local plant FS was interviewed to explain their activities in the role based on the provided process description, however when provided with the process documentation they were not able to explain the terminology and descriptions used in context with their role. To work around this, the interviews aimed to focus on their individual roles as explained in their own words to extract as much information as was possible. This was used to continuously update versions of the RPD whilst acknowledging that there are still outstanding points to clarify. Focus during this interview was therefore to gain as much information about individual roles (from each interviewee) whilst continuing to identify further stakeholder who could provide information about the overall process flow. However, as complexity reflected by the RPD was growing, it was proving more difficult to identify any one individual within the organisation (including central location and process owner) who could explain the entire process until the central project PI was identified.

Throughout the interviews it was commented how useful the diagrams were and that they provided a good overview over the process, even at early stage of the combined

RPD (see Figure 4-7) when the actual process planning process and its activities were not captured in detail.

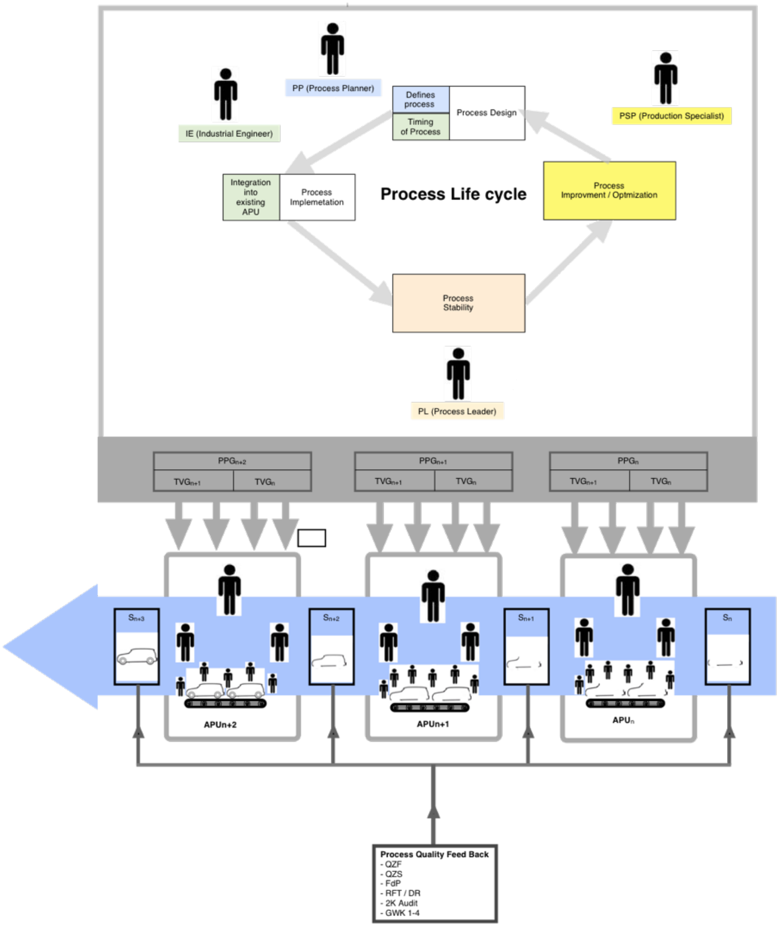


Figure 4-7: Early stage of the combined RPD

This creation of the combined RPD identified three main learning points: firstly, the creation of even a simple version of combined RPD was novel enough to be considered useful by involved stakeholders. Although the researcher was initially anxious whether such basic combined RPD would have any use, it provided an overview that allowed the stakeholders to understand their interactions with the overall process. This shows that even a basic or perceived incomplete RPD can provide valuable insights for stakeholders.

Secondly, it was identified that it was not absolutely necessary for the researcher to understand each process detail at first. Subsequent interviews do not necessarily need to strictly focus on one unknown aspect and can continue to build knowledge reflected in the RPD. That allows to continue the iterative process without focussing on one outstanding question that might not be able to be answered at this stage in the research. It demonstrated that outstanding points can be followed up later on when an interviewee is identified who can provide the required information.

Finally, an important learning point was that it is possible for stakeholders to be unaware of their lack of understanding of the documentation of a process they are part of. It was only when presented with the final RPD (see Figure 4-8) that the stakeholders actually understood their role in the entire process. In other words, this means that stakeholders might not be even aware of problems with e.g. process documentation simply because they are not aware of their interactions with the entire process. This does not mean they are not experts in the activity they perform.

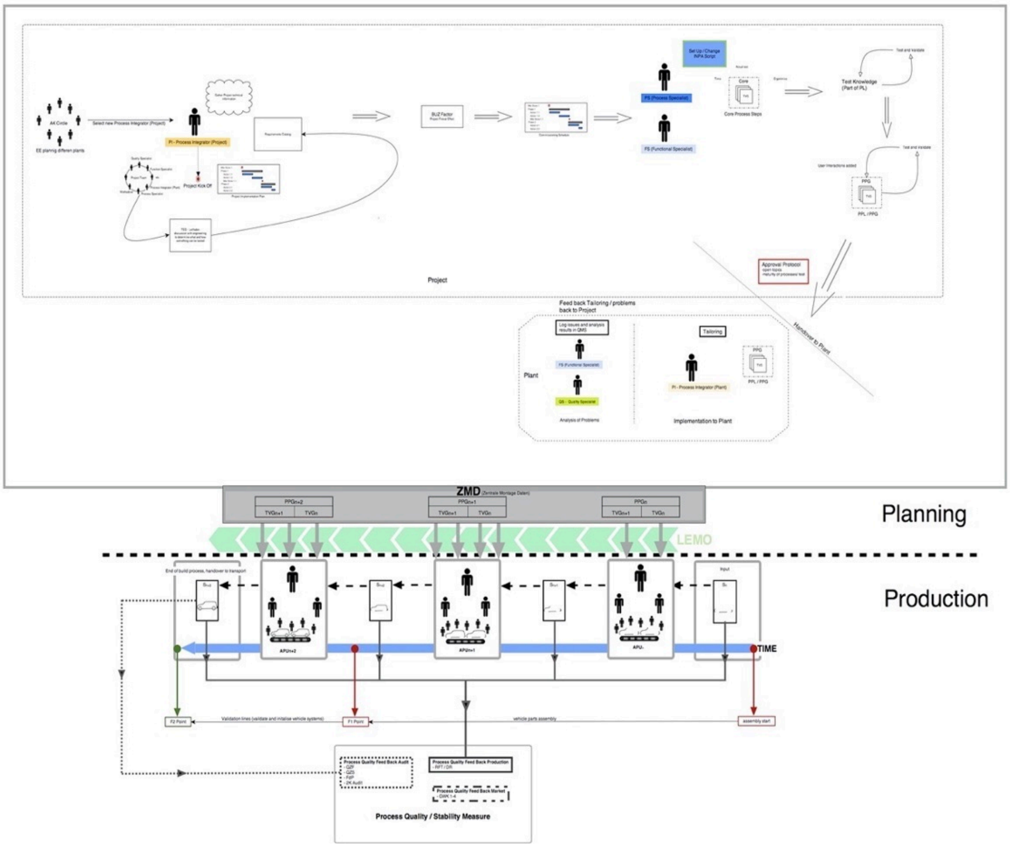


Figure 4-8: Final process overview
Larger representation of final RPD representing EE Process planning and validation overview

4.5. Test and evaluation

The evaluation phase of this iteration consisted of the iterative (stakeholder) evaluation during the development phase, as well as checks and evaluation of the complete artefact. Validation ensures that the resulting product will perform as intended in the end-user environment, referring back to the objectives. The validation of an as-is business process model can take many shapes: models are collaboratively created by the modeller and process stakeholders in which stakeholders enrich and validate the models (transitive validation) (De Vasconcelos *et al.*, 2012). As each modeller's model can take a different form and shape, it is more a general set of principles that is applied for validation rather than a quantitative, formula-based evaluation. This is even more so the case for Rich Picture Diagrams and their graphical representation of processes and should not be validated in ways that are used to e.g. validate developed software. There are no methods of comparison of Rich Picture Diagrams by measuring quality or completeness available; thus, the evaluation of such models relies on using stakeholder understating. This does not mean that models should not be evaluated at all. It is critical to use quality characteristics to identify which models will benefit from further improvement. Quality characteristics in such case could relate to assessing the following parameters of a model:

- Integrity
- Reliability
- Usability
- Correctness
- Interoperability

Another option is to use a base line as a reference point of the work and then use expert opinion (stakeholders) to compare it to previous versions (Unterkalmsteiner *et al.*, 2012). This is in line with an iterative design approach as per Checkland (Checkland and

Scholes, 1999) to capture RPD, where stakeholder (expert opinion) input on the previous version is considered and integrated during each iteration.

(1) Capture process based organisational data of one selected cross-functional process currently deployed within the research setting
(2) Create and validate the framework upper level, the process overview, by modelling the selected business process using Rich Picture Diagrams

The set-out objectives were to capture the process based organisational data of one selected cross-functional process currently deployed within the research setting (obj 2) and to create nd validate the framework upper level, the process overview, by modelling the selected business process using Rich Picture Diagrams (obj 3). The created RPD was continuously assessed throughout the iterative approach, as discussed in detail during the description of the artefact build phase. Each interview was used as an opportunity to check the researcher's understanding captured in the RPD and correct any errors. Therefore, the final version of the RPD has been evaluated for correctness throughout the creation process. As such, the feasibility of RPD application to the research environment was confirmed and an instantiation created. The final artefact was evaluated both by the involved department but also an external reviewer (a faculty member). The in-house evaluation of the artefact occurred as part of a presentation at a departmental meeting.

Interviewer "Does this rich picture diagram make sense to you?

> *"Yes it does and it's easy to understand as compared to the excel sheets. The Production Planning process should also be shown in this manner. It will be easier to communicate with employees"* (FT-S1 / Fact Team Speaker)

The RPD as a way to represent the process and offer a discussion point was well received in the interviews; it provided the process stakeholders with a complete process overview which allowed them to see how their activities fit into the overall picture. The departmental meeting provided another evaluation of the final artefact. The RPD was well received and highly rated.

4.6. Summary and conclusions

This chapter presented the first iteration and demonstrated the use of Design Science Research methodology to create an artefact that provides an overview view of a business process. The objectives for this artefact were outlined, followed by setting out the design approach that was applied to iteratively to develop the artefact. Finally, the evaluation of the artefact was discussed.

The design used an iterative approach using semi-structured interviews with process stakeholders using RPD to create a Business process overview. The iterative design approach relied on stakeholder input throughout to evaluate, improve and further develop each diagram until the diagram was complete. The final artefact was reviewed by a departmental panel and was deemed usable within in its environment. This provides the first level of the proposed framework (Figure 4-9), which gives a process overview using RPD.

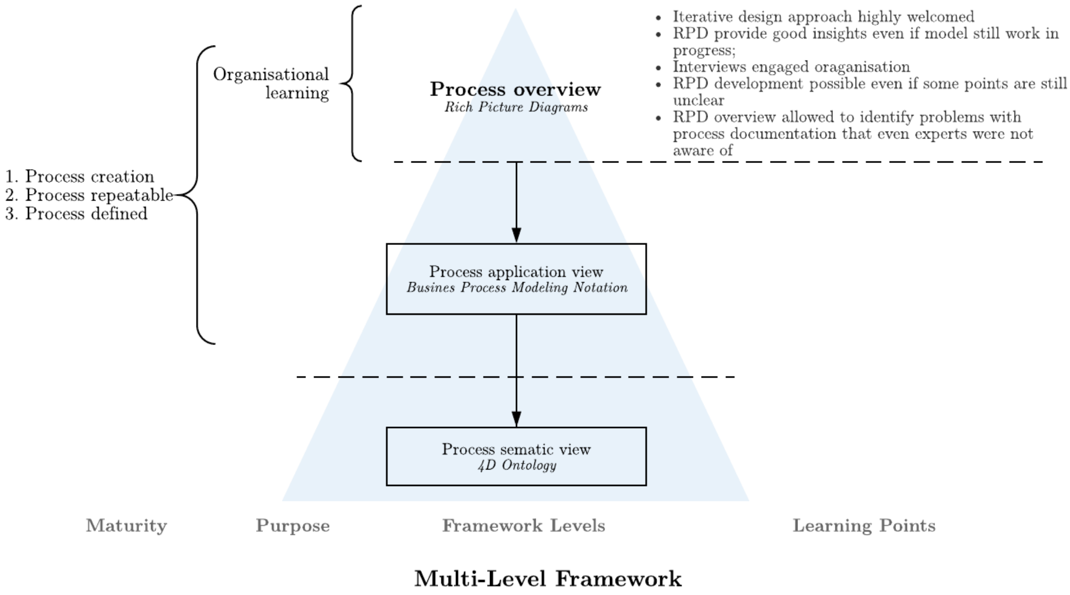


Figure 4-9: Overview of progress towards creation of MLF after first iteration

One of the key points of artefact design was to breakdown the process into two parts only to be combined again in the final stages. Initially, more focus was given to the Vehicle Process Planning process section of the process after the introduction of process documentations. However, the full process overview was able to demonstrate how planning links into the production process thus providing a more complete picture of the process

Alongside the creation of the process overview artefact, some key learning points from this iteration were made and can be summarised as follows

- Firstly, the creation of basic RPDs was highly welcome by involved stakeholders as it allowed to understand their interactions with the overall process. This shows that even a basic or perceived incomplete RPD can provide valuable insights for stakeholders.
- Secondly, it was identified outstanding points can be followed up later on when an appropriate interviewee is identified who can provide the required information. Thus, it is not absolutely necessary for the researcher to understand each process detail at

first as long as every effort is made to identify stakeholders who can be used to provide further information. The model development can still continue alongside this.

- Finally, it was identified that it is possible for stakeholders to be unaware of their own lack of understanding of the documentation of a process. A stakeholder can be still considered an expert in the activity they perform whilst not having the expert knowledge of the entire process. Thus, stakeholders might not be even aware of problems with an existing process documentation simply because they are not aware of their role within the entire process.

Furthermore, more technical learning points related to identifying that whilst it is important to follow an overall methodology, it might be critical to be able to be flexible within this overarching approach by e.g. changing to allow drawing on printouts and creating sub-divisions into the process to keep the learning and design process going. All learning points were reflected on and integrated during future work as much as possible; whilst the gathered legacy data fed more directly into the next iteration.

Chapter 5. Iteration Two: Development of a Process Application View

5.1. Chapter overview

This chapter discusses the application of Business Process Modelling Notation (BPMN) as a technique to model the Business Process overview for the creation of Electronic and Electrical (EE) vehicle production inline tests. It is the second iteration of three.

The overall aim of the research remains a framework that creates different levels of process abstraction within the organisation. This (second) iteration (see Table 5-1)builds on the legacy data gathered during the first iteration's creation of the process overview in form of an RPD. A brief summary of the research problem and objectives addressed in this iteration are given before providing a discussion of the artefact design and build. The chapter concludes with an evaluation on how the artefact meets the set of objectives and provides a discussion of the limitations and encountered difficulties.

Iteration	Objective	Design	Technique	Evaluation
1	2. Capture process based organisational legacy data 1. Model business process overview using RPD	**Artefact** Process Overview **Type** Instantiation	Rich Picture Diagram	Semi-Structured Interviews
2	3. Model business process application view using BPMN	**Artefact** Process Model **Type** Instantiation	BPMN	Semi-Structured Interviews
3	4. Model business process sematic view 4D ontologies	**Artefact** Process Model **Type** Instantiation	BORO	Competency Questions
		Artefact Modelling method **Type** Method	Mixed (literature based)	Model completeness function

Table 5-1: 2nd research iteration overview

Problem and objectives

This (second) iteration aims to create an instantiation by exploring the feasibility of applying BPMN to the outlined research environment, building on the obtained legacy data and RPDs. The artefact aims to provide the process overview and provide the middle layer of the proposed multilevel framework.

This iteration addresses objective 4 (see Figure 5-1). Objective 4 refers to creating and validating the framework mid-level, application view, by modelling the selected business process using Business Process Model Notation.

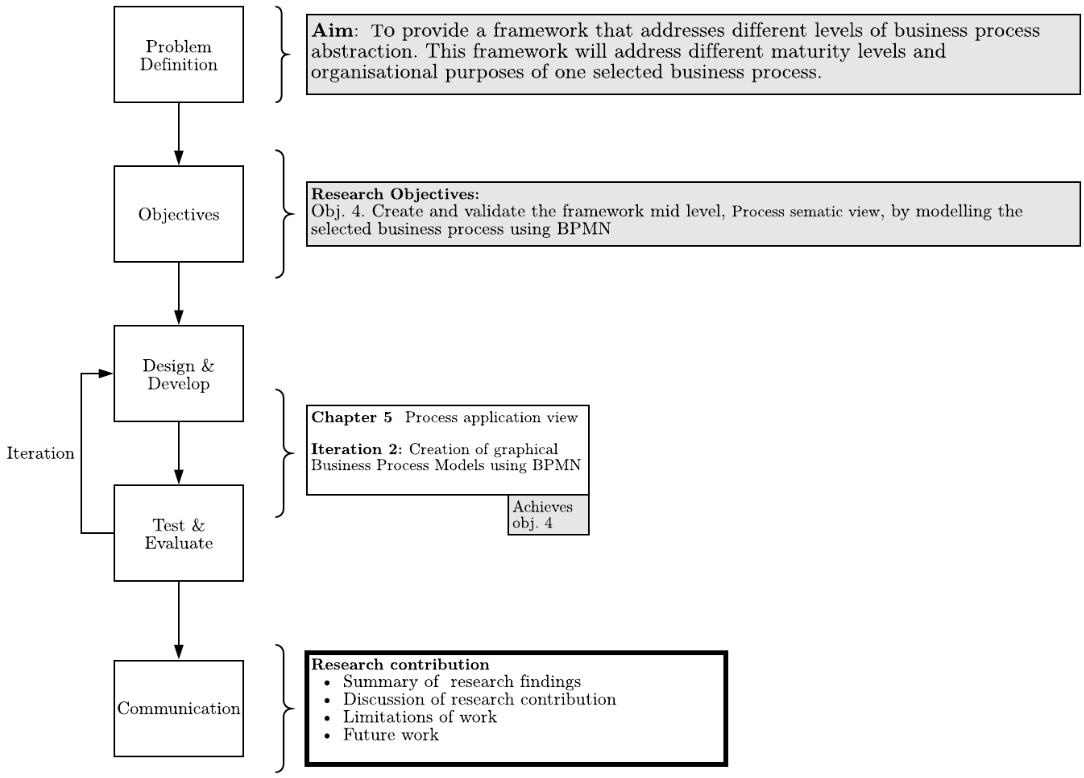


Figure 5-1: Applied DSR process
Provides an overview of the applied DSR methodology process and the five applied activities, to which the next chapters will correspond to

5.2. Artefact design

5.2.1. BPMN as a modelling technique

Business Modelling Notation (BPMN) originates from the need to create a standard technique that allows industry to display Business Processes in a way that the organisations can follow. It is built on the idea of flow charts and is the industry standard when it comes to displaying Business Process Models (BPM). BPMN dates back to 2004 and is considered one of the more ‘modern’ techniques based on a collaboration between industry and academia.

The aim is to model a process so that it can be used within an organisation to build expert process knowledge. It includes multiple process elements, such as inputs, outputs, sub-processes, activities, stakeholders, and activity flow. The model does not simulate the process, but allows to engage with the organisation and to improve stakeholders’ process knowledge.

There are several options when choosing software for creation of BPMN models. For this research, BPMN diagrams were created using Visio Paradigm (Visual Paradigm International, 2013), available with a license from Brunel University. The benefits of using this software over Microsoft Visio (Microsoft, 2013) was to allow to easily create sub-processes, which could be expanded and quickly adjusted to need. The system also allowed to export the models on a html basis, which allows exchange with researchers and stakeholders who do not hold a license.

5.2.2. Design approach

The design approach for this artefact creation aimed to mirror the methods used during the first iteration: use interviews to build a series of BPMN models. Initially, the previously created RPD was used as a tool to structure the interviews and create first versions of BPMN, aiming to use the new BPMN models as a subsequent basis for interviews. Again, the BPMN models themselves would (after multiple iterations) be the final artefact. The design approach itself tries not to be too descriptive: learning points from the first iteration showed that it is important to be flexible within the limits of the overarching methodology to allow for ongoing development.

BPMN has been chosen due to its role within industry and simultaneous ability to display and share a cross functional process - as is the case here. In addition, it allows to provide the organisation with a final diagram in line with current industry standards. Literature shows that modelling can vary depending on the ability of a modeller and the complexity of a process (Bera, 2012). BPMN has sufficient flexibility to allow the researcher to use the technique's syntax intuitively, thus allowing to create models from early on. One of the difficulties using BPMN is that there is no clearly defined end point and theoretically improvement could continue indefinitely. Furthermore, it is important to consider the issue of model validation (Kühne *et al.*, 2010). Rather than proceeding to validation after completion, it is more a matter of ongoing validation as part of the modelling process (De Vasconcelos et al., 2012; Unterkalmsteiner et al., 2012).Process validation focusses on the simulation of a process rather than a complete capture of an organisational process – therefore it is important to review it with stakeholders from within the organisation at different staged to ensure the quality of the models is maintained (Van Nuffel and De Backer, 2012).

5.3. Development using BPMN to create a process model

This second iteration was separated into two phases both focusing on modelling the planning process using Business Process Modelling Notation (BPMN). The first aimed to build on the organisational legacy data previously gathered in the first iteration; the second used an iterative approach to expand and validate it. Both of these phases used qualitative data gathered during semi-structured interviews in combination with an iteratively improved BPM. It is important to note that the process focuses primarily on the planning process and its stakeholders and does not include the production process since this was not part of the actual process documentation.

5.3.1. Description of use of semi-structured interviews for artefact creation

Semi-structured interviews were used in conjunction with the created BPM models to build on one another, similar to the creation of RPD in the first iteration (see Chapter 4). Organisational legacy data previously gathered and interpreted during the first phase was used to create questions for use within the interviews. Interaction with stakeholders was either in form of semi-structured interviews or less formal email correspondence on specific topics, if it was not possible to conduct an interview in person. A printout of the BPM was used to guide the discussion and used as a basis to draw on during the interviews; these changes were then later incorporated into the model. Outstanding questions were then addressed in the next interview and were also used as a factor in the selection of the next interviewee. In total 18 semi-structured interviews (see Table 5-1 for overview) were carried out in two different phases, spanning over seven different roles. The interviews also included two additional plants in Germany. These were held using video conferencing, however, were limited to English speakers only. This added a more comprehensive process view, not only being confined to one plant.

Interview	Role	Person	Phase
1	Plant AK Member	AK-P1	One
2	Plant Process Integrator LU	PI-P02	One
3	Plant Process Integrator L3	PI-P1	One
4	Plant Process Integrator LU	PI-P02	One
5	Plant Process Integrator L3	PI-P1	One
6	Fact Team Speaker	FT-S1	Two
7	Plant AK Member	AK-P1	Two
8	Plant Methodiker	MT-P1	Two
9	Plant Process Integrator L3	PI-P1	Two
10	Plant Process Integrator L3	PI-P1	Two
11	Plant Process Integrator L3	PI-P1	Two
12	Plant Process Integrator LU	PI-P02	Two
13	Plant Process Integrator LU	PI-P02	Two
14	Plant Functional - Process Specialist	FPS-P1	Two
15	Plant Functional - Process Specialist	FPS-P2	Two
16	Plant Process Specialist	PS-P3	Two
17	Project Process Integrator LU	PI-PR3	Two
18	Project Process Integrator LU	PI-PR3	Two

Table 5-2: 2nd Iteration overview of interviews
Overview roles and their interviews carried out within the 2nd iteration.

Similar to the first iteration, this allowed to capture and display the interviews as well as provide an overall view of the current process. As seen within the first iteration, the interactive nature of interviews was welcome and helped to focus the interview. During the second phase, the process was segmented into subprocesses, this allowed to centre each interview around identified stakeholders and focus in more detail on process elements such as roles, inputs, outputs, activities as well as their descriptions.

The interviews had therefore grossly three parts to them: firstly, to improve the overall process understanding, secondly to explore the subprocess in more detail and thirdly to check the overall model. The questions were based on their interpretation of each role and existing process documentation, e.g. the process sheet "Plan and Validate EE Production Planning". Within the process sheets certain activities were still unclear and therefore specific questions added to each interview. The general structure of the interviews was loosely defined, but allowing for flexibility if novel concepts were to arise.

Appendix 2 shows the question guide used for all interviews and transcripts of interviews. As much more detail was discussed in each interview, and to ensure that details of the subprocess were not missed, the interviews were audio recorded and transcribed, if permission was given by the interviewee. In parallel, any novel learning that was relevant to the RPD created during the first iteration was incorporated into the RPD artefact.

Figure 5-2: offers an overview of the two phases of the second iteration.

5.3.2. Business Process Model creation

The first part focussed on creating the BPM using the previously gathered organisational legacy data (RPD, role and process diagrams). A first version of a more formal graphical process representation using Business Process Modelling Notation (BPMN, discussed in Chapter 2 in more detail) was made.

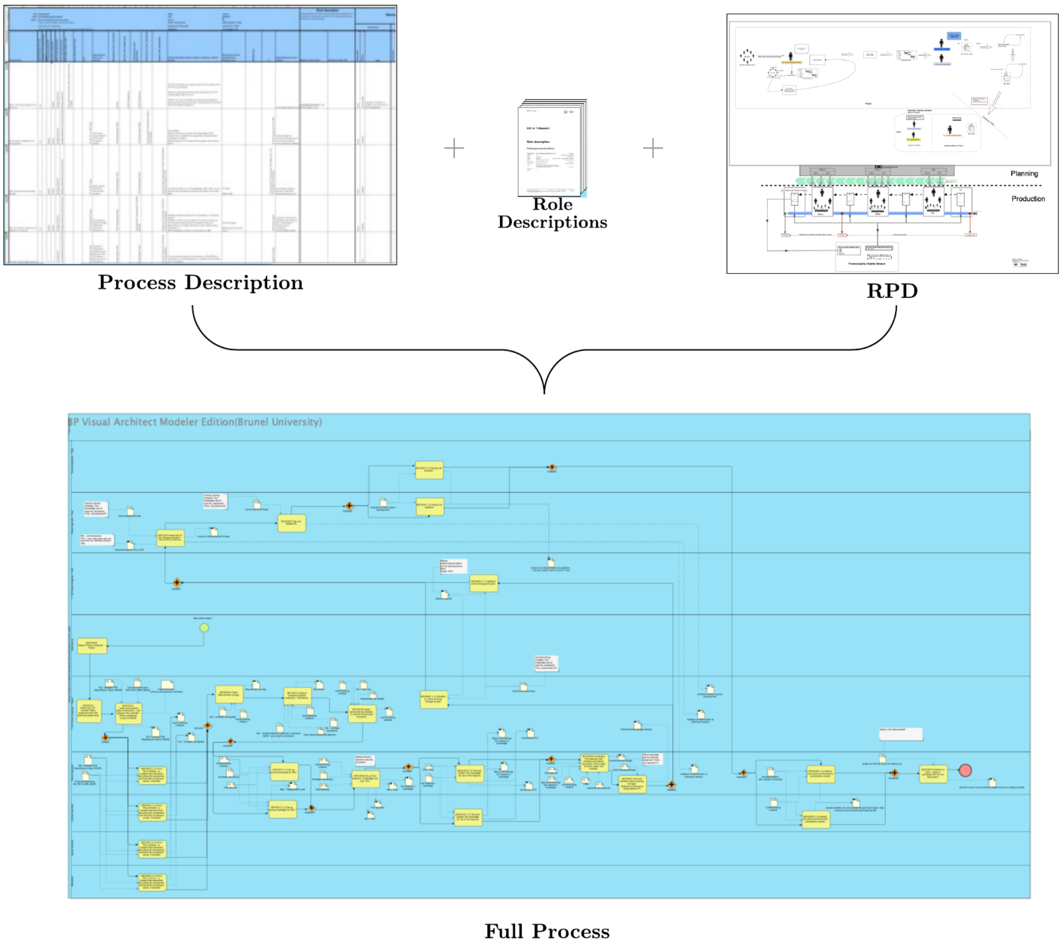


Figure 5-2: Business Process Model creation
Previously gathered organisational legacy data was used to create business process model.

BPMN was chosen due to its existing role within industry process documentation as well as intuitive nature when creating and or interpreting process models. This gave the previously modelled RPD more depth without the requirement for formal training in a novel process modelling technique. The Business Process Diagram (BPD) focused on modelling the "Plan and Validate EE Production Process". As the entire process contains too much information, the AK member and PI (local plant) selected fields from the process documentation to focus on initially (see Table 5-3-).

Selected Filed	Reason
Implementation role	The creation of the model was focused on the roles that carried out the activities (Process Step)
Process activities (Process Steps)	Showed the process flow, i.e. in what sequence the activities were carried out
Process activity ID	Mapped the activity back to the original process step within the original processes sheet provide by the organisation
Process activity description	Combination of provided activity name and description
Activity inputs / outputs	The final step in this model which was intended to present the process viewer with an easy overview on what was needed from completing an activity

Table 5-3: Fields selected from process description
To simplify the process model not all the information could be used to create BPD.

First, swim lanes were created for each of the job roles that carried out an activity. Then the process activities (process step, ID and description) were added. Finally, the inputs and outputs were added to the BPM, which completed the model. Within further informal interviews the BPD and the RPD were well received, however the BPD still proved rather complicated to interpret in its entirety. It also did not include items such as, supporting and responsible (managed) roles, nor tools used for each activity. Adding these elements would add even more complexity to the BPM, which was contrary to the initial objective of easing understating of the process. The process was modelled for the role that was carrying out (implementing) process activities. With this in mind, the creation of the BPM used the following process sheet (part of organisational legacy data provided) elements (summarised in Table 5-3).

Subsequently, five semi-structed interviews were carried out to improve the BPM iteratively (Table 5-4). The interviews focussed on improving the process understanding further.

interview	Role	Person		Length (min)	Key Aspects	Diagram
1	Plant AK Member	AK-P1	1 of 1	15	Review of RPD / BPM overview and consensus to carry on with work. Proposal for BPM segmentation into responsibilities.	BPM
2	Plant Process Integrator LU	PI-P02	1 of 2	45	Initial discussion on interpretation of the RPD into BPM and how the PPI roles fits into it	BPM
3	Plant Process Integrator L3	PI-P1	1 of 2	60	Role process steps in detail.	BPM
4	Plant Process Integrator LU	PI-P02	2 of 2	20	Looking at triggers for PPI to start his process - first part of the BPD (now with segmentation in sub-processes)	BPM
5	Plant Process Integrator L3	PI-P1	2 of 2	30	Changes to test / validation phase only happens within plant at I-300 and after.	BPM

Table 5-4: BPM interviews
focus to creation and validation of initial process Business process model using

Initially, the BPM (Figure 5-3) was discussed in the interview with the plant AK member – who is also the team lead for the department within the plant. During this interview an agreement was made to continue the selected process; access and full support from the relevant team was given to allow to gather further information and create a final BPM.

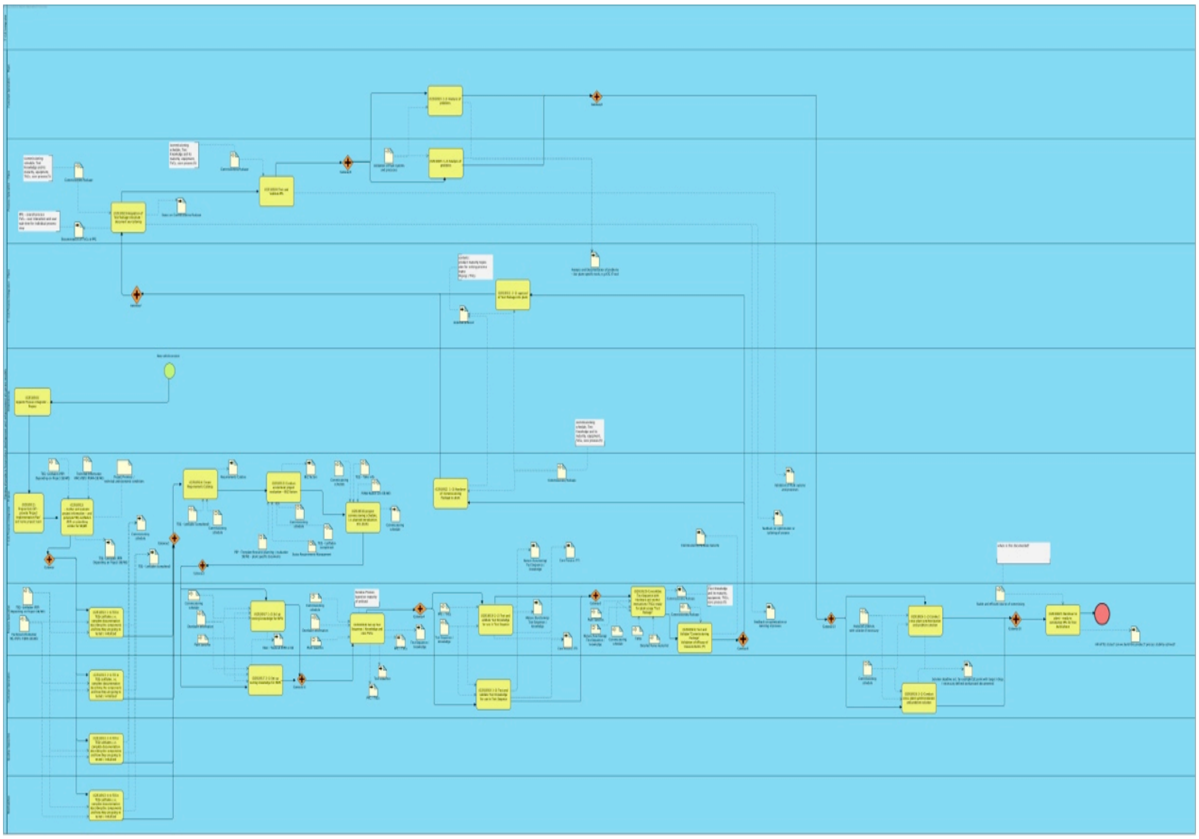


Figure 5-3: Business Process Model
The first attempt to model business process, disapplying the complete process on one level, i.e. not segmented into subprocesses

The final artefact and findings were then presented in the team meeting. This initial meeting also gave rise to the suggestion to segment the process to allow for key responsibilities and their processes to be easily identifiable – this would helpful if any issues were discovered when the process is carried out. This suggestion was supported by the results from other interviews as it became apparent that the overall process was too complex to discuss entirely with others. Therefore, the segmentation was implemented. The remaining four interviews were able to focus on answering questions relating to individual roles and activities, centred around the process and the current process RPD model. Each interview only resulted in minor changed to the diagram model during this stage. The most significant change was the creation of segmentation of the process (Figure 5-4). This segmentation was mainly reviewed during the fourth interview, with the Project Integrator (PI) and allowed to obtain very positive feedback on the implementation of segmentation and its quality. Throughout this part of the 2nd iteration, it was important to identify stakeholders who have a high level of overall process knowledge. Although these first interviews showed that creating a BPM was *possible* and improved the visual representation, it was noticed that understanding could be further improved by re-structuring the way the information was presented. The BPM would be subdivided into a task-orientated and subprocess-orientated level.

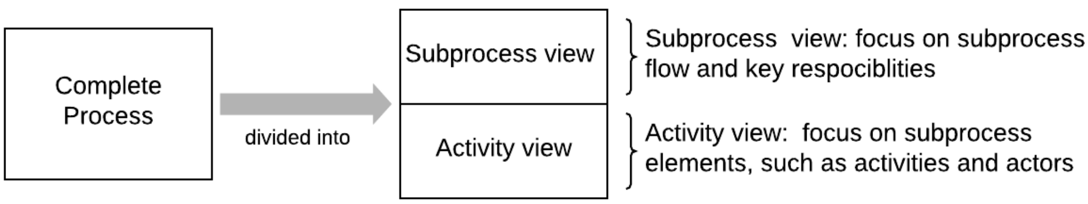


Figure 5-4: Hierarchy comparison between first and second iteration
Addition of Mid-Level: Sub Process view was added to “group” information into units to aid structuring of information and ease understanding.

5.3.3. Segmenting the business process model

The process model was segmented into 18 subprocesses (see Table 5-5): each subprocess focusing on process elements such as, activity description, Subprocess ID, tools, input. All subprocess display the same information as was previous displayed in the overall BPM. The segmentation did not include any more or less information than the previous BPM at this stage.

Role	Sub-Process	Interviews	Phase 1	Phase 2
AK	1	2	1	1
PI	7	11	4	7
PS	8	4	0	4
FS	2	3	0	3

Table 5-5: List of modelled subprocesses
Provides a list of all modelled subprocesses and roles that carry them out and how may interviews where carry out.

There were 13 interviews conducted during this segmentation of the process (see Table 5-6). This phase of model creation started out with five semi structured interviews which focussed on gathering process context, such as test system architecture or model classifications. This was followed by seven interviews focussing on detailed process information such as explanation of activities or inputs and wording thereof. The final interview was used to help validate the complete process; although similar to the first iteration, each preceding interview was also used to assess whether the presented BPM or RPD had any particular areas requiring improvement or used any incorrect terminology.

Interview	Type	Role	Person		Use as Input
1	Scope Process	Fach Team Speaker	FT-S1	1 of 1	BPM
2	Scope Process	Plant AK Member	AK-P1	1 of 1	BPM / RPD
3	Scope Process	Plant Methodiker	MT-P1	1 of 1	BPM / RPD
4	Scope Process	Plant Process Integrator L3-1	PI-P1	1 of 3	BPM
5	Scope Process	Plant Process Integrator L3-2	PI-P1	2 of 3	BPM / RPD
6	Process Detail	Plant Process Integrator L3-3	PI-P1	3 of 3	BPM
7	Process Detail	Plant Process Integrator LU-1	PI-P02	1 of 2	BPM
8	Process Detail	Plant Process Integrator LU-2	PI-P02	2 of 2	RPD
9	Process Detail	Plant Functional - Process Specialist -1	FPS-P1	1 of 1	BPM
10	Process Detail	Plant Functional - Process Specialist -2	FPS-P2	1 of 1	BPM
11	Process Detail	Plant Process Specialist -3	PS-P3	1 of 1	BPM
12	Process Detail	Project Process Integrator LU-1	PI-PR3	1 of 2	BPM
13	Model Vaildation	Project Process Integrator LU-2	PI-PR3	2 of 2	BPM

Table 5-6: Interviews

The new level of abstraction (activity level) showed details of each individual process activities. Modelling of the individual activities brought its own challenges due to complexity of each activity, their interactions with different process elements and present ambiguity within the process documentation. However, this also means that there was more opportunity to identify potentially problematic areas within the process documentation any problems and explore those in more detail.

During the creation of two-tier model, the new second level namely the “sub-process” only focussed on representing the process flow and respective activity management role. The management role was selected based on being a key position of responsibility (Garretson and Harmon, 2005; Cabanillas, Resinas and Ruiz-Cortés, 2011) and based on information available within the process sheet. Table 5-7 summarises all process sheet fields and which level of abstraction they were used. This created a mid-level which similar to the process flow displayed in the RPD ‘type’ representation, as it allows for an overview without losing the viewer in the detail of the overall process.

Process Sheet Field	Used in BPM	Top Level	Sub Level
Process step ID	x	x	x
Process step	x	x	x
Typical duration (PT in h)	-	-	-
Completion venue (plant/head office)	-	-	-
Predecessor process ID	x	x	
Successor process ID	x	x	
Start as per Synchroplan	-	-	-
End as per Synchroplan	-	-	-
Start criteria (event / time)	-	-	-
End criteria (event / time)	-	-	-
from	x	-	x
Input delivery (from role / system)	x	-	x
Management (role / department)	x	x	x
Decision (role / department)	x	-	x
Implementation (role / department)	x	-	x
Information to (role / department)	x	-	x
Support (role / department)	x	-	x
Activity description (input / method / frequency / system / output)	x	-	x
Binding documents (specifications, directives, etc.)	x	-	x
Binding tools	x	-	x
to	x	-	x
Output delivery (to role / system)	x	-	x
Milestones in Synchroplan	-	-	-
Interface to other PAs	-	-	-
Implementation	-	-	-
Tailoring	-	-	-
Notes	-	-	-

Table 5-7: Process documentation fields and their application to models
Summary of which items where used to model the process and which were used or left out.

Interviews with stakeholders were set up to specifically discuss individual process activities and focused on the process activity's stakeholders, inputs / outputs and tools. The Sub-Level activity models were based on four semi-structured interviews, with questions directly aimed on activity descriptions. This included questions on activity inputs, out puts and tools used during each activity. Throughout this stage, additional elements, such as activities, were added to subprocess when it became clear that something was missing. This allowed to highlight small errors which were fed back to the process owner, in this case the project PI.

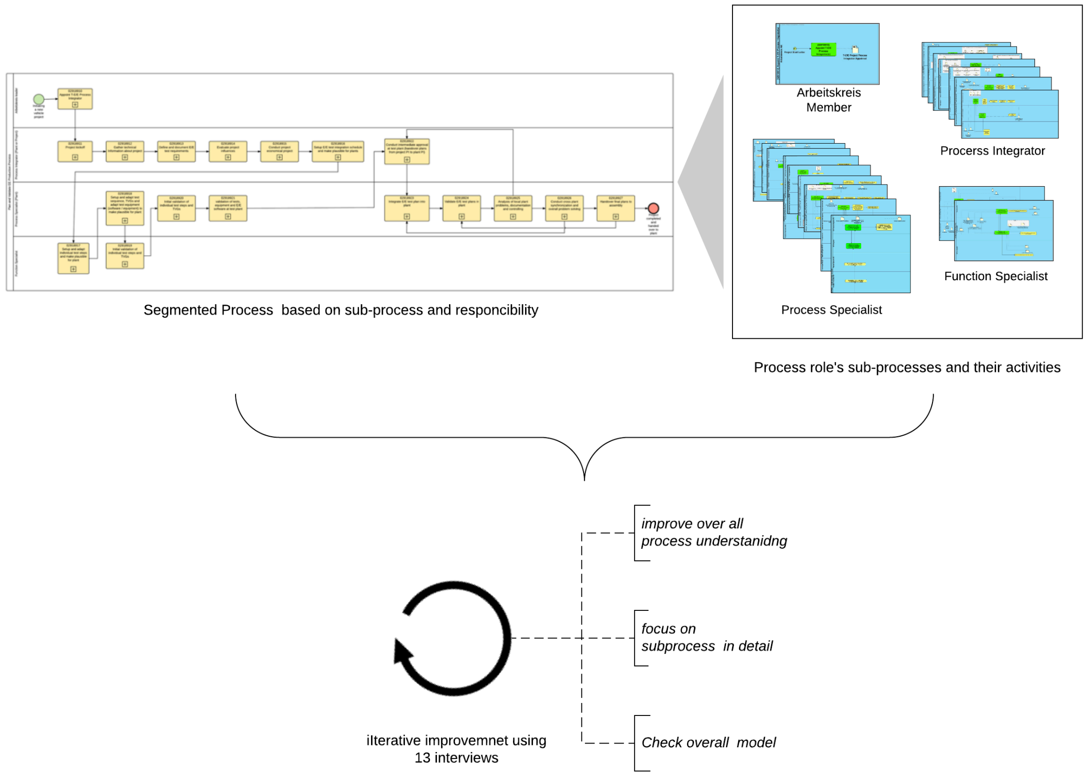


Figure 5-5: Segmenting the business process model

The following Figures (Figure 5-6 and Figure 5-7) show the final artefact in more detail, with Figure 5-6 demonstrating the subprocess view and Figure 5-7 an example of the activity view.

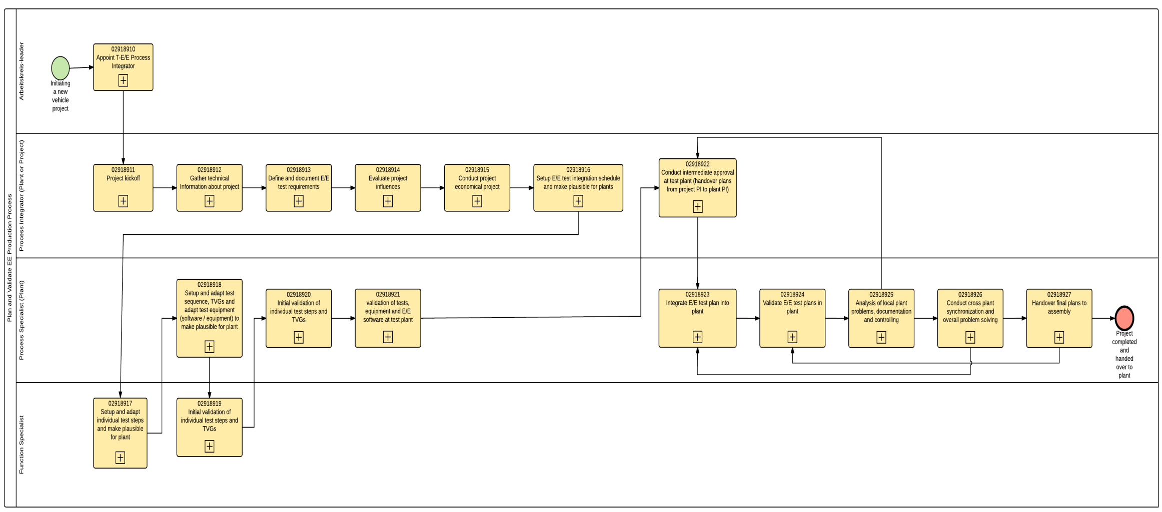


Figure 5-6: Mid-Level: Sub Process
View of final BPD of EE Process Planning Process

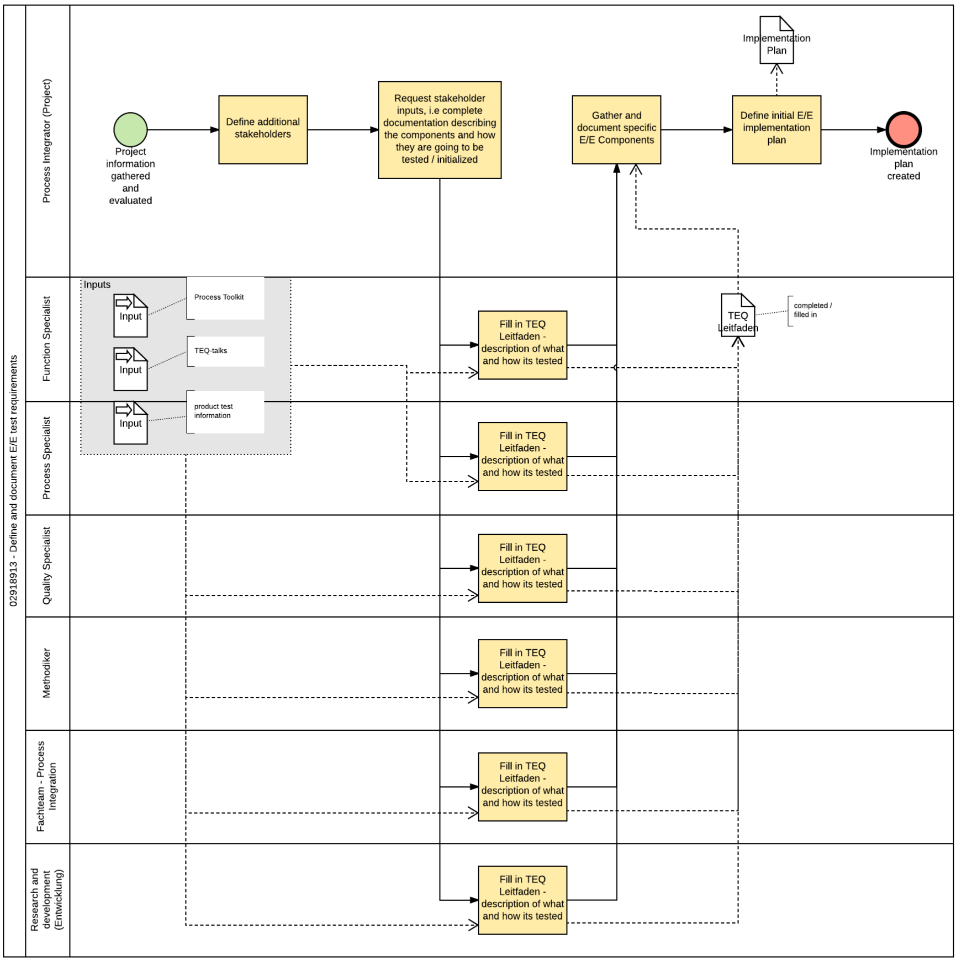


Figure 5-7: Lower Level: Activity view.

BPD example, shows process activity in more detail

Finally, as this iteration was also used to update the RPD artefact, the updated version of the RPD following the second iteration can be seen in Figure 5-8. It demonstrates the updated process planning overview RPD.

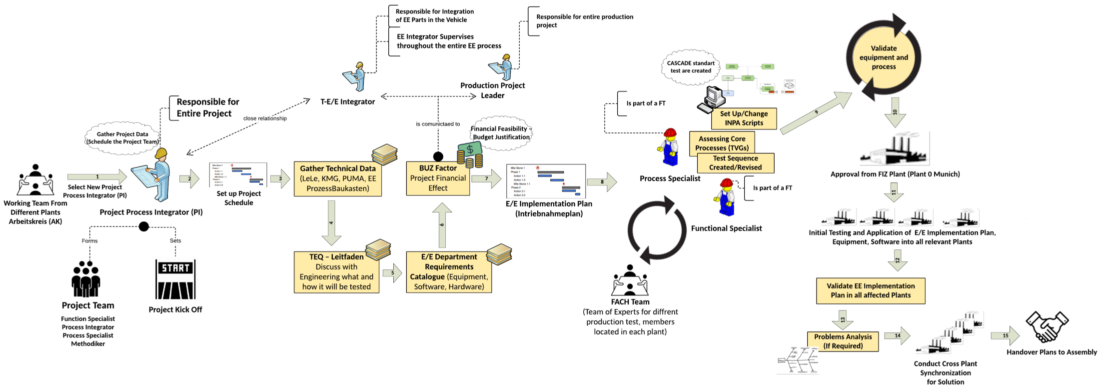


Figure 5-8: Process overview diagram update

Final Rich Picture Diagram showing the EE process planning process after it has been updated with the final

Learning points

There were several learning points identified during this iteration: firstly, segmentation helped to explain the process better by allowing to focus the discussion in interviews around subprocesses and their stakeholders. In contrast to using a process model which displays the entire process this allowed to avoid distractions and identify specific areas to centre around those areas. Secondly, whilst the overall process understanding improved with each interview and iteration and with this there was an improved understanding of the complexity. This learning point mainly relates to realising the limitations of BPMN as a technique and the inability to combine all the legacy data at once. Finally, during the interviews, it became obvious that the process sheet was actually not widely used. It was not communicated well throughout the organisation and difficult to follow.

Interviewer: "*Are you (..) aware about the Process Sheets (9_1-9_2)?*"

> "*No never seen them*" (FPS-P2 / Functional and Process Specialist)

It also became apparent that some of the limited use of the process sheets was related to the translation of the process sheets which made interpretation difficult. After discussion, activity descriptions were therefor changed to ease understanding (listed in

Table 5-8). Therefore, it was possible to use the interviews to clarify and improve description of terms used in the process sheet, thus changing a process sheet that was rarely used to a format that is more readily available and uses terminology that was understood and agreed amongst the process stake holders.

Proces Step (activity)	Description Before	Description After
2918911	Conduct Project Management for E/E Process Planning	Project Kick Off
2918912	Gather and Collect Relevant Information for Project	Technical Information Gathered About Project
2918913	Agree and Document Necessities for E/E Testing and Commissioning	Define and Document Requirements for E/E Testing
2918916	Set up initial commissioning schedule and make plausible for plants	Set up E/E Test Integration and make plausible for plants
2918920	Integrate course of commissioning into equipment and frequency independently of plant and make plausible in plant (integration into commissioning and test stand)	Integrate E/E Test Process with Equipment and make plausible for Plants
2918921	Initially test and validate course of commissioning	Validation of Tests, Equipment and E/E Software at Test Plant
2918923	Integrate course of bringing into all effected plant	Integrate E/E Test Plans into all Plants
2918924	Validate Course of commissioning in all relevant plants	Validate E/E Test Plans in all Plants
2918927	Handover course of commissioning to Construction	Handover Final Plans To Assembly

Table 5-8: Activity description changes.
Clarification on descriptions out of the original process sheet, which were subsequently changed after discussions with stakeholders to correct for translation.

It was further established that the contribution of certain roles could be better emphasised by increasing the size of the cartoon representation within the RPD to draw attention to them. This adaption of the RPD to include additional aspects of a role (e.g. more important contribution) captures a novel understanding of the process, which were not specified within the process sheet.

5.4. Test and Evaluation

The evaluation phase of the second iteration was principally based on an iterative stakeholder evaluation of the Business Process Models (BPM) throughout the development phase. The set-out objective was to Model the business process application view using BPMN (obj. 4.).

The evaluation can be segmented into three phases, (1) using current models and stakeholder evaluation, (2a) a move to capturing stakeholders' semi-structured interviews and focus on capturing different aspects of the process form multiple stakeholders followed by an (2b) overall check by the process owner to ensure model quality and completeness. And finally (3) a presentation to the department and academic experts.

The initial phase continued an approach very similar to the one applied in the first iteration, providing a Business Process Model and (when a new stakeholder was interviewed use of the business process overview). The stakeholder evaluated the process model and provided additional information to also validate the researcher's interpterion of the process. Once the process was segmented into subprocesses and gaps in understanding were highlighted, interviews were broader and explored, e.g. the details of vehicle test and what tools and hardware was used. Further information as to how different vehicle models are sub-categized and how this affects test content was also gathered. The focus subsequently moved to understating subprocess elements in detail as identified buy the process stakeholders. The following transcript shows the level of clarification that was sought to clarify aspects of the process during the interviews:

918, what do you mean Setting up Test Sequence and Core TVGs and in the previous step it was Test Knowledge? What's the difference? Shouldn't the FS and PS be present in this task?

> "*Test Sequence is setting the sequence of the A Test B Test F1 etc. Including the position. CASCADE is also implemented into the plant.*" (PI-PR3 / Process Owner / Process Integrator Project – LU)

What's the difference between 918 and 919?

> "*918 is implementing into a plant and 919 is executing that run.*" (PI-PR3 / Process Owner / Process Integrator Project – LU)

When comparing the created artefact to old methods of process documentation, there was a clear preference for the artefact. Interviewees expressed that when considering the old documentation, they

> "*No saw them recently and wanted to close them*" and found them "*Not useful at all should be depicted graphically. It is far too complicated*" (FT-S1 / Fact Team Speaker)

In contrast, when referring to the created artefacts they expressed that

> "*Graphically depicting this will be very useful.*" (FT-S1 / Fact Team Speaker)

and when reviewing the BPMN they stated,

> "*I agree with the Process Sheets and it is very useful and easy to follow*" (PI-P02 / Process Integrator Plant 0 - LU)

After the artefact was considered almost complete, a final step was included with the process owner's check and validation of the model, again in format of an interview. This included going through each process model (overall process model and subprocess models). After the evaluation by the process owner, in a format similar to what has been used for Chapter 4, a presentation to bother the department and two academic experts was undertaken. This provided an overview of the entire design approach with in-depth discussion, as well as presentation of the created artefact. The approach and learning outcomes were discussed and appraised, in form of both an updated *Process Overview* (RPD) and *Process Application view* (BPMN). The created artefact and its development were well received by the departmental panel and the experts.

5.5. Summary and conclusions

This chapter presented the second iteration the use DSR to design, develop and evaluate of the *Process Application view* using BPMN. An iterative design approach was applied using semi-structured interviews as part of the development and evaluation process. Each iteration of the BPM was evaluated by relevant stakeholders, providing either improvement suggestions or acceptance of the model. The final model was reviewed by the process owner to ensure its overall quality, in addition it was presented to a wider panel. This iteration builds on the learning and legacy data from the first iteration, and in itself provided new learning to take forward to the final iteration.

Figure 5-9 provides an overview of the two phases of artefact development in this iteration.

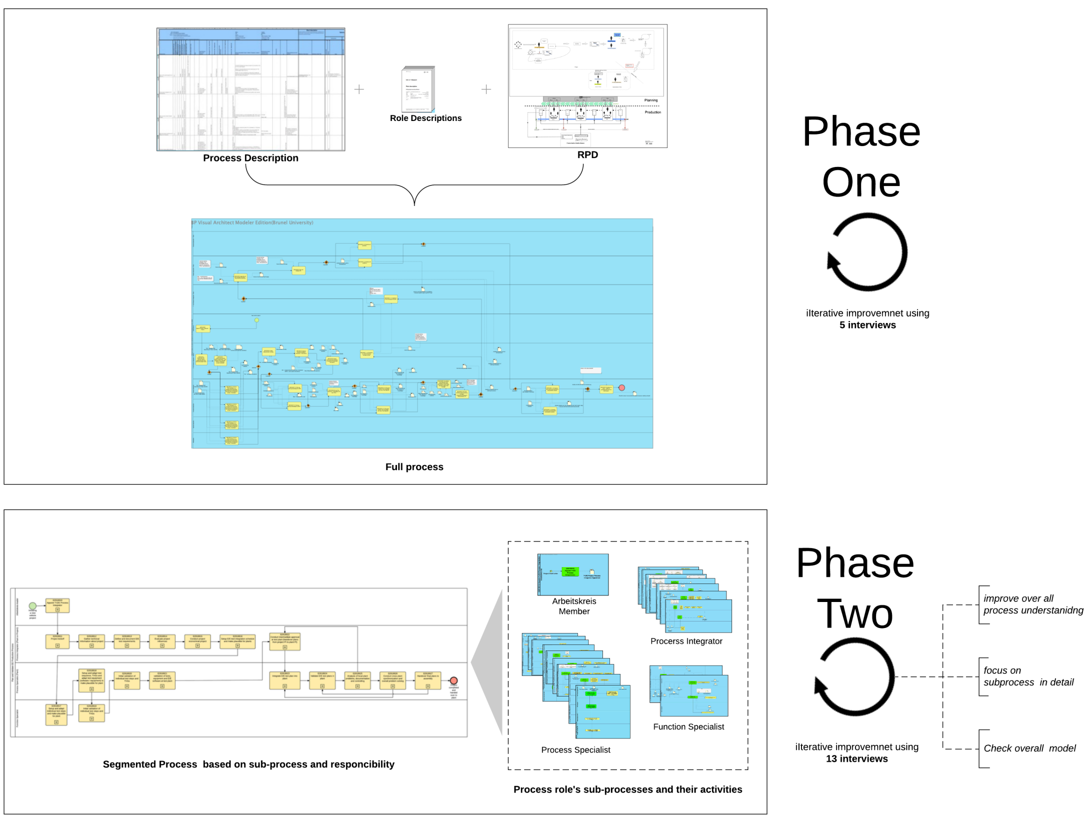


Figure 5-9: Overview of 2nd Iteration's subdivision into two phases

The artefact created in this iteration provides the second layer of the proposed framework, which gives the process application view (Figure 5-10).

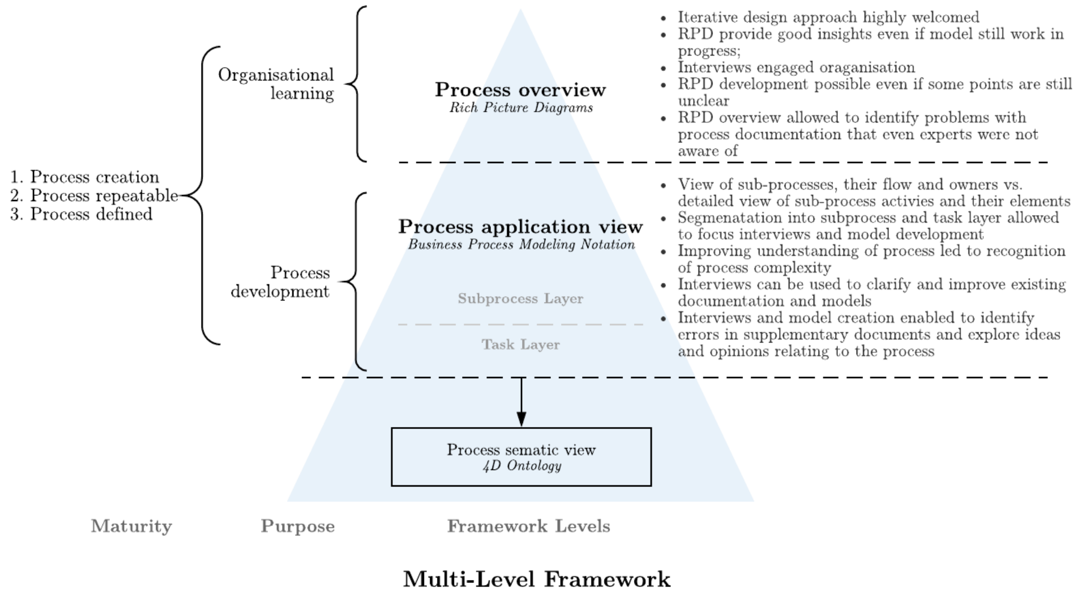


Figure 5-10: Progress towards creation of MLF after second iteration

There were several learning points identified, as briefly outlined here:

- Firstly, segmentation allowed to explain the process better by having more focussed discussion in interviews around subprocesses and their stakeholders. This allowed to specifically target areas that required improvement and manage the interviewees time better
- Secondly – it was recognised that although the overall process understanding improved with each interview, this also led to a recognition of the existing complexity. This allowed to recognise the limitations of BPMN as a technique and develop approaches to address this. This of course links into the above learning point that segmentation can help overall understanding.
- Finally, the interviews allowed to identify existing misconceptions – and identified for example that existing process documentation had not been in fact used. The interviews and artefact creation process allowed to identify some of the reasons

for not using the process sheets – not all related to the actual representation of the process – such as poor translation of the sheets which made interpretation difficult. This learning point relates do the strength of using interviews and a developing model in identifying problems that stakeholders and the researcher did not know existed when the research was initiated.

As previously, this iteration generated not only legacy data and an application view of the process – it also allowed to update and improve the previously generated RPD artefact (see Chapter 4) and generated knowledge that was important for the next iteration.

Chapter 6. Iteration Three: Development of a Process Semantic view

6.1. Overview

This Chapter discusses an approach to create ontologies as well as the actual creation of 4D business ontologies based on previously gathered and created organisational legacy data in Chapters 4 and 5. It is the last iteration of three with the overall aim to provide a framework to model business process to suit the required level of abstraction required by the organisation. This iteration provides the lowest level of the framework with the intent to provide the necessary language that can be easily understood and implemented into IT systems, as difficulty with IT implementation often arises as processes are written in a different language (Dijkman, Rosa and Reijers, 2012).Furthermore, the creation and validation of ontologies for process modelling based on the previously captured business processes within a vehicle production plant is discussed. This approach aims to provide the additional layer to expand on the hierarchical multi-layered framework that has been discussed in the previous chapters using RPD and BPMN.

Iteration	Objective	Design	Technique	Evaluation
1	2. Capture process based organisational legacy data 1. Model business process overview using RPD	**Artefact** Process Overview **Type** Instantiation	Rich Picture Diagram	Semi-Structured Interviews
2	3. Model business process application view using BPMN	**Artefact** Process Model **Type** Instantiation	BPMN	Semi-Structured Interviews
3	4. Model business process sematic view 4D ontologies	**Artefact** Process Model **Type** Instantiation	BORO	Competency Questions
		Artefact Modelling method **Type** Method	Mixed (literature based)	Model completeness function

Table 6-1: Research iterations
Provides an overview of all iterations, with focus on iteration 3, its artefacts, techniques and evaluation.

Problem and objectives

The overarching research aim is to develop a framework that can aid to represent and understand different levels of business process abstraction within an organisation. This (third) iteration focusses on the creation of an overview of the EE vehicle production in-line tests process using Business Object Reference Ontology (BORO) a 4-Dimensional ontology. This iteration aims to create an instantiation by exploring the feasibility of 4D ontology application to the outlined research environment. The final artefact aims to provide process models for IT integration and provide the lowest layer of the proposed multilevel framework. This iteration addresses objective 5 (see Figure 6-1). This refers to the creation and evaluation of the framework lower level, semantic view, by modelling the business process using 4D ontologies based on previously gathered organisational data (Chapters 4 and 5).

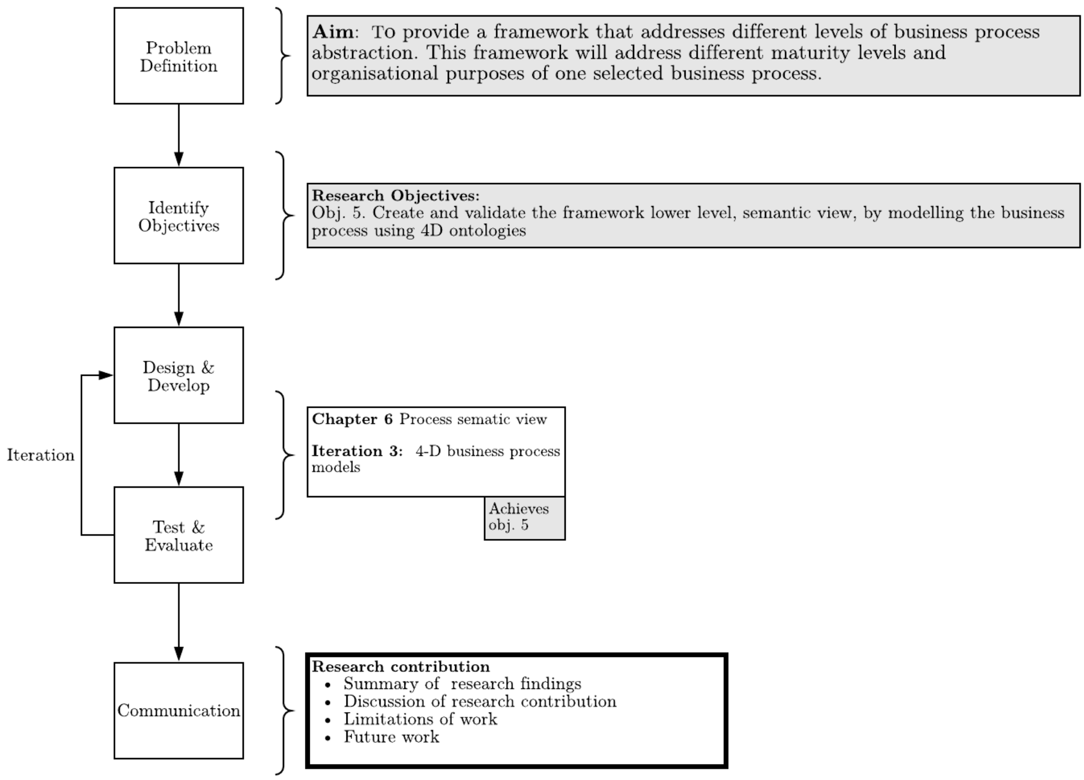


Figure 6-1: Applied DSR process
Provides an overview of the applied DSR methodology process and the five applied activities

6.2. 4D Ontology as a Business Process Modelling technique

6.2.1. Selection of upper level Ontology

Ontologies allow to capture the richness and complexity of the world by looking at the elements, the hierarchy of the elements and their relationships between each other. All ontologies try to conceptualise the real world. Whilst a human individual has learnt for example that a cup has a certain shape and characteristics and can also be classified more widely as a container or vessel – this information is not immediately available to a model. Ontologies of a cup can be given all the information relating to shape, characteristics and how it fits into the hierarchy of crockery to model a cup with all its inherent features.

One problem that arises with conventional three-dimensional ontologies is that they do not capture change in relationship to time. This means that the evolution or history of the system is not reflected. 4D ontologies capture this 'fourth dimension' (time), allowing this information to be incorporated into the model. This allows comparisons to previous conditions. (West, 2009; Cesare and Partridge, 2016) 4D ontologies would thus be able to hold information about the 'history' of the cup: for example, the information that the cup was broken, and then glued together would be available. Business Object Reference Ontology (BORO) is the approach designed to be used in the context of modelling business processes (Partridge, 1996).

IT implementation is an essential element to capture data points and information correctly, allowing to identify bottle necks in processes. Ontologies provide the necessary language which can be easily understood and implemented into IT systems (see REF-CH-2). Unified modelling language (UML) is an example of language that uses class diagrams to represent the ontologies (Eriksson and Penker, 2000; Fowler, 2003;

Development *et al.*, 2004). A further benefit of ontologies and IT system is a reduction in the need for resources: information and analysis can be conducted in an automated way rather than relying on manual assessment. Models created using ontologies are richer, and show the relationships between tasks better – the complex relationships between tasks and elements becomes difficult to represent and understand using conventional models (Aldin and de Cesare, 2011).

6.2.2. Business Object Reference Ontology structure

Within BORO, UML class diagrams are used in order to model the ontologies, although BORO specific terms have been developed to create BORO-UML (BUML). The upper level ontology structure is based on objects having elements, tuples and types.

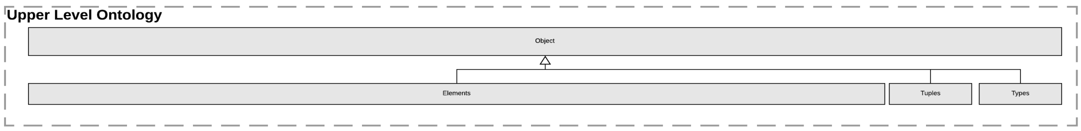


Figure 6-2: Upper Level Ontology

Elements can be defined as individual object and the space it occupies over time. This allows for the ontology to capture the changes to the object over time, making this 4D rather than 3D. An example would be person (the object) changing his role within an organisation. Not only was the change in role captured but also when it happened, therefore providing a chronological history. Events trigger such change to an element over time (see Figure 6-3). **Tuples** are used to capture the relationship between elements. In this conceptualisation, roles are considered elements, in which a role and a person can occupy the same space within time (see Figure 6-3) and **Types** categorise sets of objects.

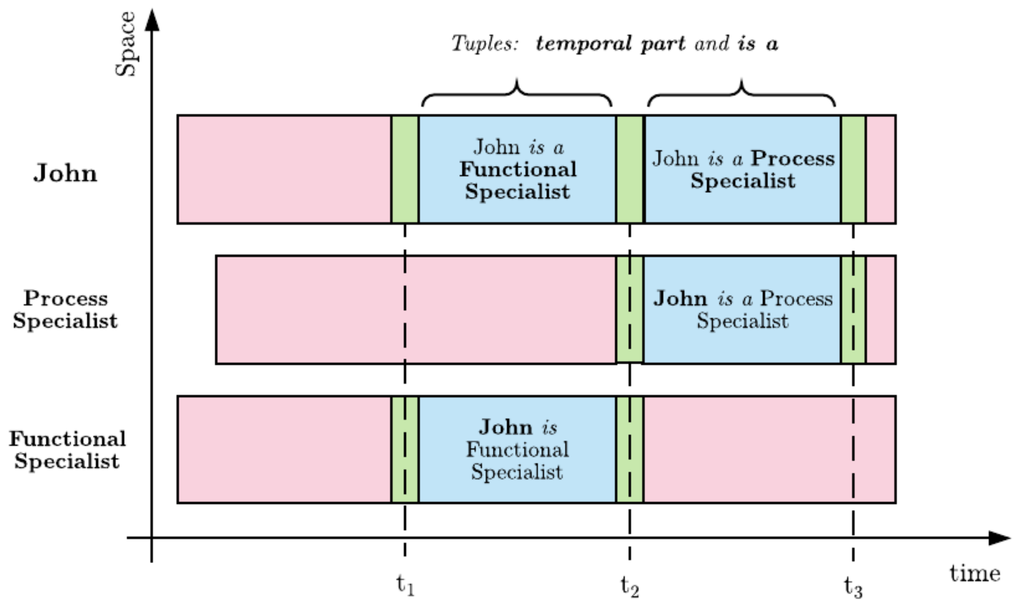


Figure 6-3: Time space diagram
Displays how both objects (person and role) occupy the same space and how it changes over time. In addition, it highlights the relationship between the two.

6.3. Ontology design process

When different people model the same scenario, it is likely that the resulting models are different, especially as these become more complex. Ontologies attempt to conceptualise the real world by defining it (Gemino and Wand, 2004). There is debate in the literature as to whether the ideal approach is to expand existing ontologies or to create new ones (Vegetti *et al.*, 2016). Most ontologies tend not to follow any formal creation approach, with a common view that the creation is considered an acquired art form (Soares and Fonseca, 2011).

Grüninger & Fox (Grüninger *et al.*, 1995) argue that defining the ontology's purpose and final use allows for a structured creation and validation approach. Since then, there have been multiple studies examining the ontology creation process, all highlighting the lack of consensus on a common approach (Fernandes, Guizzardi and Guizzardi, 2010; Soares and Fonseca, 2011; Vegetti *et al.*, 2016). However, Vegetti *et al.* (Vegetti *et al.*,

2016) argue that three basic steps can be found in most of them, namely: gathering specification, development and evaluation, which correlates with well-established top down design stages (Figure 6-4).

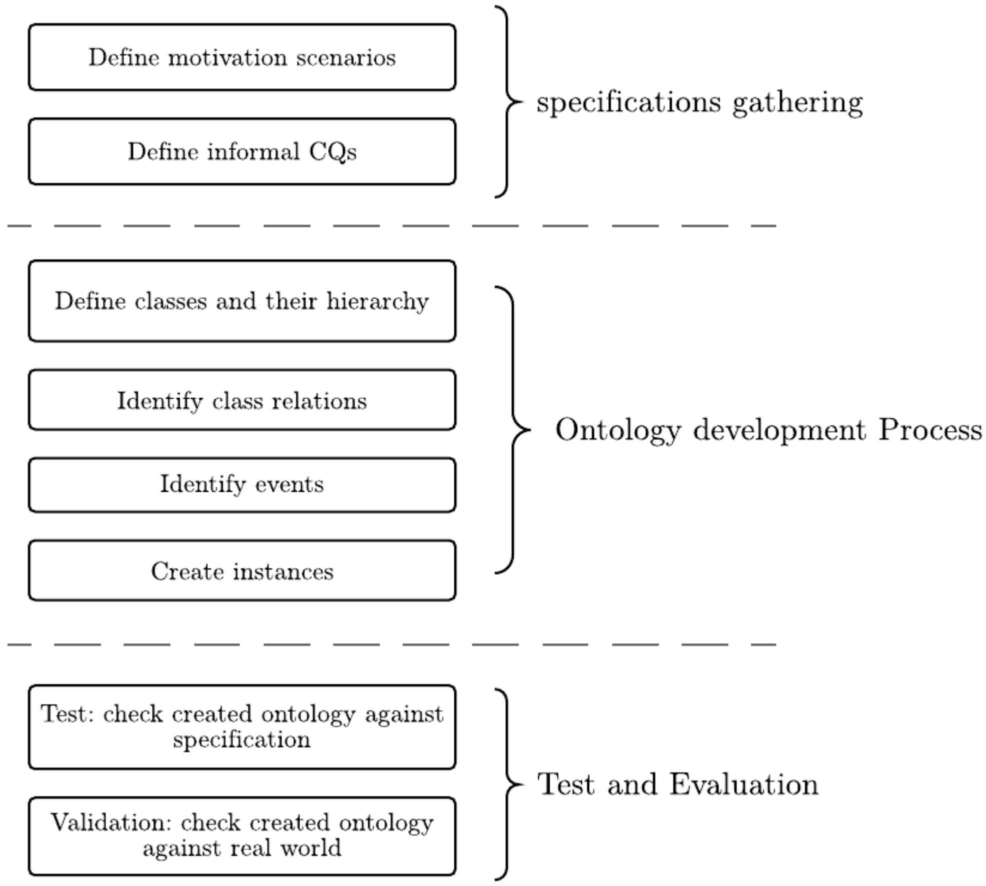


Figure 6-4: Ontology creation process
mapped against design research methodology. Highlights the activities from the ontology design process (Brusa *et al.*, 2008) and groups them in sub processes to fit in to the Design Research Methodology (Peffers *et al.*, 2008). This also highlights the different steps that need to be applied to ensure a consistent approach to modelling the 4D ontology

The three main elements when building an ontology are i) gathering requirements ii) creation of the development of the ontology and iii) test and validation of the ontology. The important first step is to first capture the motivational scenario and thus to understand the rationale.

Just as with all modelling techniques, it needs to be ensured that was has been captured is valid. Following a structured approach can thus help to create a higher quality model. Brusa's description of the ontology design process (Brusa *et al.*, 2008) provides a modelling approach that can be followed by the novice modeller. Sometimes learning by doing something proves more important than following structured instructions. However, as one becomes more familiar with the ontology approach, and learns from the previous approaches, each modeller is likely to develop their own 'structured approach', even if not formally captured. To summarise, whilst structure remains important creating models is a learning process itself and modellers (and their models) get better the more they model.

6.3.1. Specifications Gathering

This phase has grossly two steps, the first the creation of motivational scenarios which gather and structure organisational information that is then used in at the later phase, the ontology development. The second step, the creation of Competency Questions (CQ). A set of question, which the ontology is aiming to answer and can thus be used to determine the completeness of the ontology (Grüninger *et al.*, 1995).

Motivational scenarios are based on the environment (in this case industry) which provides the rationale explaining why either an extension of existing ontologies is used or a new one should be created. It provides the reasoning for the objectives of the ontological solution in a way that the organization can understand them (Grüninger *et al.*, 1995). The actual capturing of motivational scenarios can be carried out using Brusa's proposed template. This allows to capture (1) the most important information in a (2) concise way. In this research, the template is based on a detailed understating of the business process, carried out in the previous research cycle (see Chapters 4 and 5).

This description template was modified to be applicable to the process used within this research (see Table 6-2). In Brusa's original work, the template was based on interviews – for this project the basis for the description template is the previously gathered and created organisational legacy data discussed in previous chapters.

Scenario number	*Scenario identification*
Name	Scenario name
Description	Brief scenario description
Site	Location where the scenario occurs
Actors	People that participate in that scenario
Group	Groups of actors that participate in that scenario
Pre-requirements	Set of requirements that must always be met prior to the execution of the scenario
Requirements	List of needs required to execute the scenario
Normal sequence	Set of tasks that define the normal sequence of the scenario
Post-condition	Condition that must always be true just after the execution of the normal sequence
Exceptions	Actions that are not part of normal operations or standards
Main problems	List of possible problems caused by semantic heterogeneity
Main terms	List of possible terms and concepts related to the scenario

Table 6-2: Motivational Scenario description template
The template allows the modeler to focus on the most important information to form the motivation scenarios in a concise way. Depending on the environment complexity, multiple scenarios can be created. It provides a tool for capturing a single or multiple scenarios bevor conceptualising an ontology (Brusa *et al.*, 2008)

Brusa *et al.* described a framework for the application of motivational scenario gathering and provides a template for creation of CQs (Brusa *et al.*, 2008), which this project is based on. As a next step, the CQs were rationalised based on the motivational scenarios and previous findings.

Competency questions are based on the motivation scenarios and can be seen as *requirements* the ontology should answer. CQs evaluate the solution's ontological ability to express itself, i.e. providing a means of evaluating the ontological solution ability to express the initial problems captured in the motivational scenarios (Grüninger *et al.*, 1995). The creation of a set of competency questions is based on the already established motivational scenario(s) based on the initial research cycle outcomes in conjunction with a set of questions form Grüninger & Fox, which are based on creating activity and organisational based ontologies (see Table 6-3).

Along the principles first described by Grüninger and Fox (Grüninger *et al.*, 1995), the CQs were grouped into activity-based and organisational CQ. The CQs were collected based on a review of the literature and relevant results from Chapter 4, as highlighted in the Figures.

Activity Ontology
1. Temporal projection: Given a set of actions that occur at different points in time in the future, what are the properties of resources and activities at arbitrary points in time?
2. Planning and scheduling: what sequences of activities must be completed to achieve some goal? - At what times must these activities be initiated and terminated?
3. Execution monitoring and external events: What are the effects of the occurrence of external and unexpected events (such as machine breakdown or the unavailability of resources) on a plan or schedule
4. Time-based competition: we want to design an enterprise that minimises the cycle time for a product. This is essentially the task of finding a minimum duration plan that minimised action occurrences and maximises occurrence of activities.

Organisational Ontology
1. What activity must a particular role perform?
2. Is it possible for a role to perform an activity in some situations? - That is, does the role have the ability to perform the activity?
3. in order to perform a particular activity, whose permission is needed?
4. Is a role allowed to perform an activity in some situation?
5. What goals is an agent committed to achieving?
6. What authority constraints are necessary amongst a set of roles in order to achieve a goal?
7. What goals are solitarily unachievable for a given role: - That is, what goals are unachievable using a plan that contains only activities that the role is capable of performing? - Such goals require the assistance of other agents to achieve them
8. What goals are achievable by a role given the effects of activities that the other roles are capable of performing?
9. If a goal is solitarily unachievable for a given role, what roles are required to assist the role in achieving the goal?

Table 6-3: Competency Questions
originally described by Grüninger & Fox

6.3.2. Ontology design and development process

Once the requirements have been gathered in form of the motivational scenarios and competency questions, the conceptualisation of the ontology can begin. UML based class diagrams are well-known and used as a modelling technique to capture the 4D ontologies (Fowler, 2003; Development *et al.*, 2004; Beradi, Calvanese and Degiacomo, 2005; Brusa *et al.*, 2008; West, 2009; Partridge, Mitchell and de Cesare, 2012; Cesare and Partridge, 2016). The creation process is broken down into the following four steps (see Figure 6-4);

this aims to provide a more structured approach and improve consistency and quality of the model.

Initially, the class hierarchy for your problem domain is defined; this allows to capture all classes that are required and confirms their relationship within each hierarchy. This defines all processes, activities, subprocesses, tasks etc with consideration of how the elements are structured. This is then followed by the identification of relationships between classes. Finally, events need to be identified and then instances created. Events allow to clarify the temporal relationships between elements by creating e.g. a start or end point (creation and dissolution). Finally, instances are created – this allows to use information from the scenarios captured earlier and is therefore specific to the problem domain and thus provides the actual process model in full. The ontology design process is completed by verifying and then validating the ontology.

6.3.3. Test and Evaluation

The subprocess contains two activities: verification and validation. Verification checks the specification against the implementation and validation checks the specifications against the real world. Both are described in more detail below.

Test (verification) is set out to prove the consistency, completeness and the conciseness of the ontology. Ontological consistency refers to the fact that no contradictions can be inferred and the representation follows a consistent approach. The ontology is also checked against its completeness ensuring that the representation is not incomplete (Brusa *et al.*, 2008). This representation should be explicit, allowing for axioms to be inferred. Finally, conciseness ensures that that the ontology has no redundant parts, i.e. no unnecessary parts. In order to verify the ontology, structural measurement or use of a graphical representation (such as class diagrams) can be used. Secondly, using an iterative process itself can be seen as an internal step of verification which allows for issues to be flagged up early on, and changed or corrected in the next iteration

Validation is carried out using the previously specified CQs and checking them against the designed ontology's ability to answer them. It is acceptable to use human judgement to determine if the ontology answers a CQ. The validation can be either performed using computational models, using an IT system or based on a visual assessment on a diagram. The literature proposes Competency Questions (CQs) as query-based questions (Brusa *et al.*, 2008; Heravi, Lycett and de Cesare, 2014). These establish the need for a new ontology, or at least alterations to existing ontologies. They also provide a method of evaluation by investigating the ontological expressiveness by answering questions. This evaluates the ability of an ontology to satisfy its previously defined purpose and use.

Finally the CQ confidence degree can be calculated using the following formula (Brusa *et al.*, 2008).

$$\frac{g = \sum_{1}^{e} \left[{\left(\sum_{1}^{n} q\right)} \big/ {n} \right]}{e}$$

g = confidence degree

n =number of CQ (1 = yes / 0.5= maybe/ 0 = no)

q = degree of answers to

e = number of domain experts

6.4. Development of a 4D Process Model

A 4D ontology of the Plan and Validate EE Production Process was created following the design discussed above. The creation of the ontology was based around the template scenarios used during the competency question setting. The model focusses on two different aspects: the mid-level focusses on the sub process flow and who is responsible for this task, whereas the lower level (task view) focusses on inputs and outputs of each task as well as who carries out the task. It was important to capture the difference between those who manage the sub-process and those who carry out individual tasks within each sub-process whilst designing the 4D ontology. The relationship between a sub-process and its associated parts was also important to be reflected in the ontology. A single scenario was created for the sub-process view (mid-level) and several scenarios were used to show the lower level (task) view (see Figure 6-5).

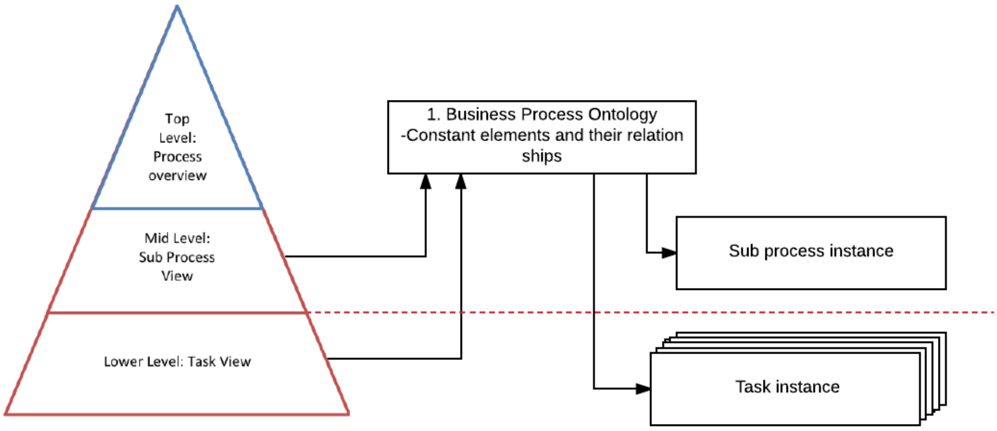


Figure 6-5: Business process ontology structure

6.4.1. Gathering specifications

To gather specifications, firstly motivational scenarios and secondly Competency Questions (CQ) ought to be defined (see Figure 6-6)

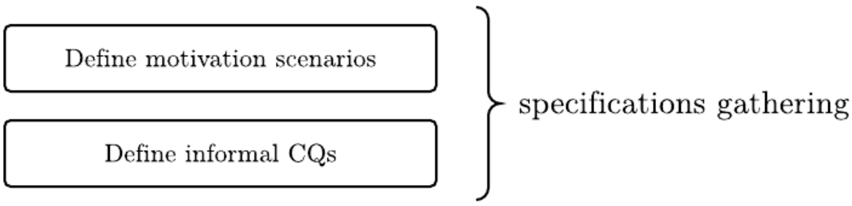


Figure 6-6: Specification gathering
Specification gathering is the first step out of the ontology design process.

The initial step captured the motivational scenarios using the process models from the second iteration (see Figure 6-9). Two different types of scenarios were captured: one of the complete process based on subprocesses (example shown in Figure 6-7) and the other based on its tasks (example shown in Figure 6-8).

Scenario number	*T-EE_9-1*
Name	Plan and Validate E/E Production Process
Description	New vehicle project inline production test creation for electrical and electronics by the central project team and the subsequent hand over to the production plant
Site	central research and development / project team with hand over to the applicable plant
Actors	Arbeitskreis-leader Process Integrator (Plant or Project) Process Specialist (Plant) Function Specialist
Group	Not applicable
Pre-requirements	No project defined
Normal sequence	02918910 - Appoint T-E/E Process Integrator 02918911 - Project Kick Off 02918912 - Technical Information Gathered About Project 02918913 - Define and Document Requirements for E/E Testing 02918914 - Evaluating any influencing on the Project 02918915 - Conduct Economical Project Evaluation (BUZ-Factor) 02918916 - Set up E/E Implementation Plan Schedule and make it plausible for plants 02918917 -Set up / adapt Test Content and make plausible for Plant 02918918 - Set up Testing sequence and applicable TVGs, and adapt E/E software / equipment and make plausible for plant 02918919 - Initial validation of Test steps and TVGs 02918920 - Create E/E Test Content and make plausible for affected Plants 02918921 - Validation of Implementation Plan (test content, core process and software) at Test Plant 02918922 - Conduct Initial handover between FIZ and Plants 02918923 - Integrate E/E implementation plan into plants 02918924 - Validate the E/E implementation plan into all Plants 02918925 - Analysis of Local plant problems, documentation and controlling 02918926 - Conduct cross plant synchronization and overall problem solving 02918927 - Handover final plan to assembly 02918928 - conduct lessons learned (LeLe)
Post-condition	E/E Production Process validated and implemented
Main terms	E/E, Fach Team, Arbeitskreis

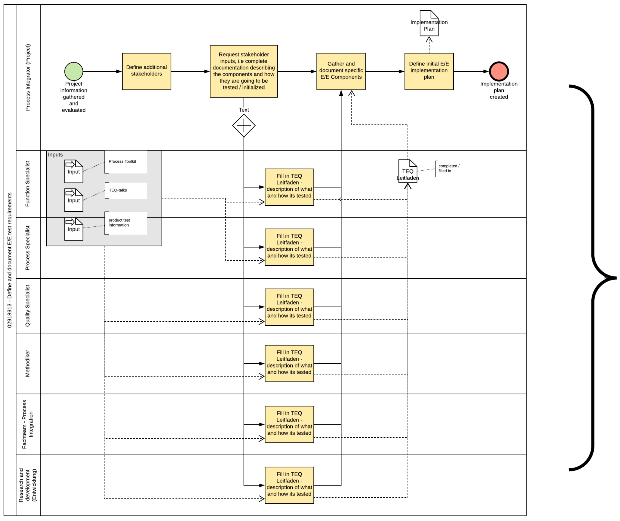
Figure 6-7: Scenario capturing subprocesses

Scenario number	*02918913*
Name	Define and Document Requirements for E/E Testing
Description	Completes the technical test requirements and the initial project implementation plan
Site	Central research and development / project team
Actors	Process Integrator (Project) Function Specialist Process Specialist Quality Specialist Methodiker Research and development (Entwicklung)
Group	Fachteam - Process Integration
Pre-requirements	1. Project team must be established 2. Access to Process-Baukasten 3. KMG project available 4. TEQ-Leitfaden
Normal sequence	Define additional stakeholders Request stakeholder inputs, i.e. complete documentation describing the components and how they are going to be tested / initialized Fill in TEQ Leitfaden - description of what and how its tested Gather and document specific E/E Components Define initial E/E implementation plan
Post-condition	Initial E/E implementation plan defined
Main terms	TEQ-Leitfaden, Fachteam, E/E implementation plan, E/E, KMG, Baukasten

Figure 6-8: Scenario capturing tasks

To start with, peripheral information such as scenario number, name, description and site was gathered. This was followed by listing all process actors and any groups involved: the information regarding sites where the process was carried out and the roles involved was extracted. In a similar way, information about the involved groups was included for the scenario template. Next, the pre-requirements were captured; these were the inputs to the process. It is then necessary to capture the sequence of subprocess or tasks as well as – subsequently - their inputs. Finally, additional terminology was captured. At this point, it became apparent that some fields such as process description are more likely to be used by those not familiar with the process – therefore additional information is required to allow understanding. Whereas for someone with detailed knowledge of the process, these fields do not add any additional value.

Figure 6-9 demonstrates an example of how a BPM was used to create a motivational scenario.



Businesss Process Diagram

Scenario number	02918913
Name	Define and Document Requirements fro E/E Testing
Description	Competes the technical test requirments and the intial project implemation plan
Site	Central research and development / project team
Actors	Process Integrator (Project) Function Specialist Process Specialist Quality Specialist Methodiker Research and development (Entwicklung)
Group	Fachteam - Process Integration
Pre-requirements	1. Project team must be established 2. Access to Process-Baukasten 3. KMG project avaible 4. TEQ-Leitfaden
Normal sequence	Define additional stakeholders Request stakeholder inputs, i.e complete documentation describing the components and how they are going to be tested / initialized Fill in TEQ Leitfaden - description of what and how its tested Gather and document specific E/E Components Define initial E/E implementation plan
Post-condition	Initial E/E implemenation plan defined
Main terms	TEQ-Leitfaden, Fachteam, E/E implentaion plan, E/E, KMG, Baukasten

Scenario

Figure 6-9: Subprocess Diagram conversion into scenario

The next step involved development of Competency Questions which will be later on used during validation. The final ontology's ability to answer those CQ will be used to as a factor to assess the ontology's completeness. In order to create the competency questions, the previously created scenarios were used together with CQs described in the literature. The CQs were subdivided into activity and organisational CQs. The final list for this research included 16 CQs, as shown in Table 6-4. Both the CQs and the scenario template were applied in order to design the ontology.

Activity based competency questions
1. Are the process / sub-process resources clearly defined?
a. What resources are required at a certain point of time in order to carry out an activity?
i. What tools (SW / HW) are required?
ii. What man power / job roles are required?
2. Is the process / sub-process goal clearly defined?
a. What activities have to be completed in order to achieve the process goal?
i. What is the activity sequence?
ii. How many activities in each process?
iii. How can you determine that an activity is completed?
iv. What is the activity input?
v. What is the activity output?
3. Is the process / sub-process execution time clearly defined?
a. Is the activity cycle time defined?
4. What are the effects of unexpected (tool breakdown, or person missing etc.) events to the process / sub-process?
a. Are unexpected events defined in the model?

Organisational based competency questions
1. What activities must a role perform?
a. Can you determine what role carried out an instance of the activity?
2. Is the stakeholder able (pre occupied / trained) to perform an activity?
a. Can the relationship between the activity and the required training easily be established?
3. What process / sub-process goals cannot be achieved by a single stakeholder?
a. What sub process requires more than one role/stakeholder?
b. What sub process requires only a single role?
4. What process / sub-processes need other stake holders input?
a. Does each process highlight inputs from other stakeholders?
5. Is the process / sub process cross functional? (newly added to show process complexity)
a. Are other departments involved (provide input, carry out an activity or receive an output)?
6. Do all process stakeholders speak the same language?
a. How many languages are spoken?
b. Is the level of spoken and written communication easy to interpret?
c. Is the process description clearly understandable so that the it can be followed?
7. Is the process known to the organisation?
a. Do process stakeholders know the process and explain it?
b. Can a non-process stakeholder understand the overall process goal?

Table 6-4: Rationalised CQ
divided into activity and organisational based competency questions

6.4.2. Ontology Development

Ontology Development is segmented into four steps that were followed sequentially (see Figure 6-10). Starting with defining the classes and their hierarchy, and then identifying their relationship. Then events are added allowing objects to occupy the same space and to compare how they change over time. Finally, instances are created based on the previous steps. Colour coding was used in order to simplify the ontology and linking different models together, otherwise the models would become too big and difficult to understand. The approach was adopted to go through the first three steps to develop the ontology, and then modelling Instances separately using the colour coding show the connection between classes (identical classes used).

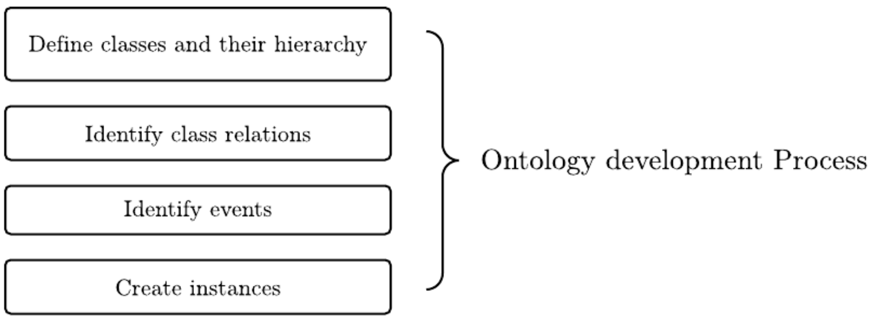


Figure 6-10: Ontology development process

The following Figures provide visual aids to understand the details of the ontology development and should be used alongside the description.

Definition of classes and their hierarchy

Motivational scenarios captured previously contain all the information to understand the process and elements that create the classes. They are used to define the classes and their hierarchy. In the beginning classes for process elements are created; these are: Outputs (process outputs), Inputs (process inputs), Persons (the actual person carrying out the process), Roles (roles carrying out an activity) and Activities. However, out of those, activities is the only class which contains a hierarchy defining processes down to tasks (see Figure 6-11).

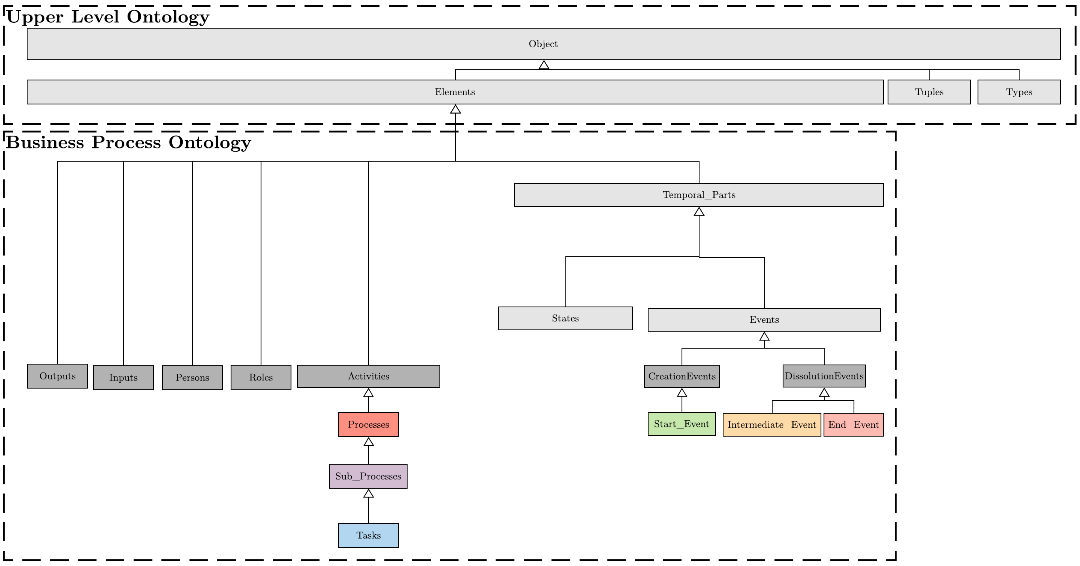


Figure 6-11: Definition of classes and class hierarchy

Identification of class relations

After defining the hierarchy of classes, their relationships were defined, as highlighted in yellow (see Figure 6-12). The relationships such as e.g. between tasks and subprocesses and/or process and subprocesses were added to the ontology. This also allowed to create relationships that define roles that carry out activities or a person who performs a role. All activities have Inputs and create Outputs, and these relationships are therefore defined. These relationships allow to capture context of elements and are then later used to determine states during instances. Figure 6-12 provides an overview of an example how relationships are defined, with an insert demonstrating relationships between tasks and activities in more detail.

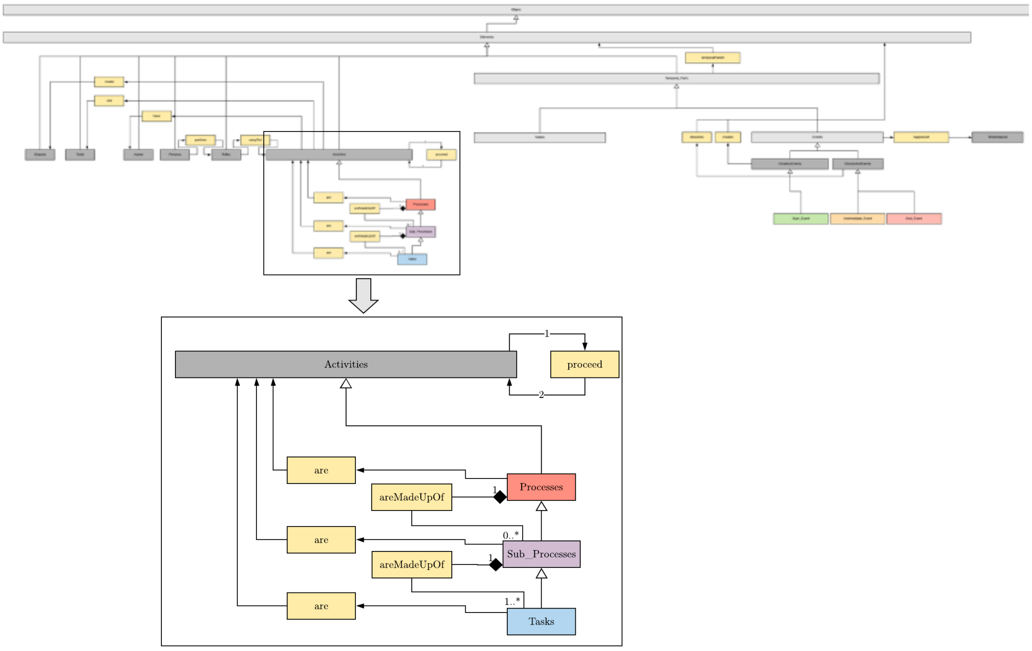


Figure 6-12: Example of relations between classes.
The top shows an example of an overview how relationships between classes (in yellow) are defined, the insert at the bottom provides a more detailed view of the hierarchy of one process and how the classes relate to each other within this ontology

Identification of events

Events are identified to demonstrate a creation or dissolution of a state against a time point, thus determining the state of an element. For the events class hierarchy, BORO was used. The three basic process events start (green), intermediate (amber) and end (red) are used to define the limitations (within time) of an element (as shown in Figure 6-13).

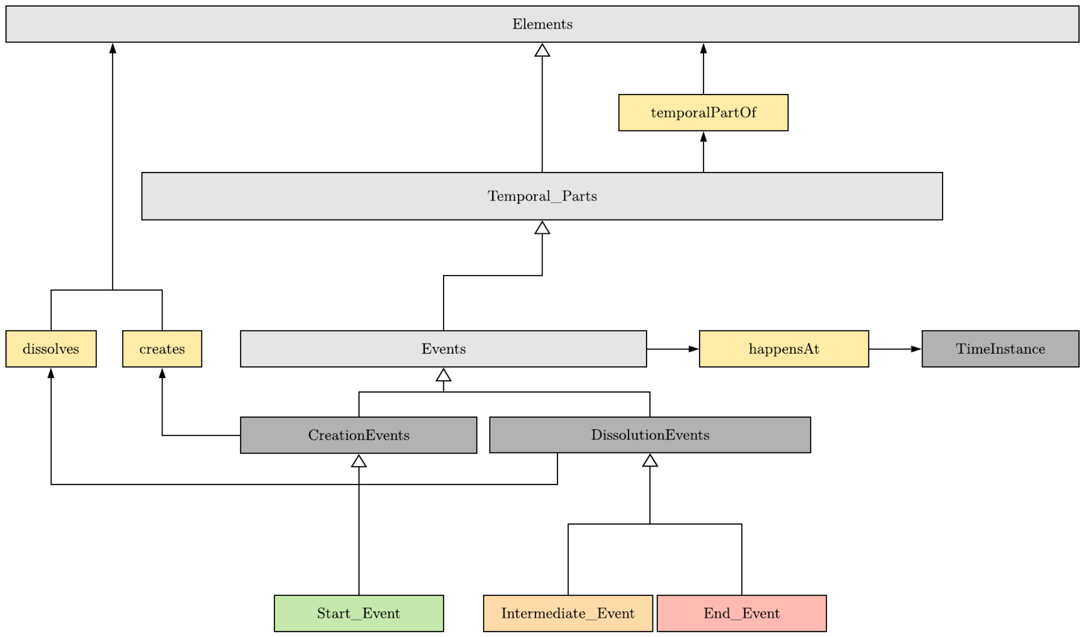


Figure 6-13: Definition of events within ontology
start (green), intermediate (amber) and end (red) are shown and define the limitations in time for the state of an element

Creation of instances

Instances are created based on the previously gathered scenarios and were grouped into four categories: Task, Role, Input and Output. For each category, multiple instances were created. For each relationship between different elements, such as Roles and Persons, Tasks and Roles, Tasks and Inputs and/or Tasks and Outputs states were created. Each state was limited by events. Figure 6-14 shows examples of how a task (A), role (B), input (C) and output (D) are be defined. Figure 6-15 demonstrates part of the instance without the events to provide more detail, allowing to focus on the state created.

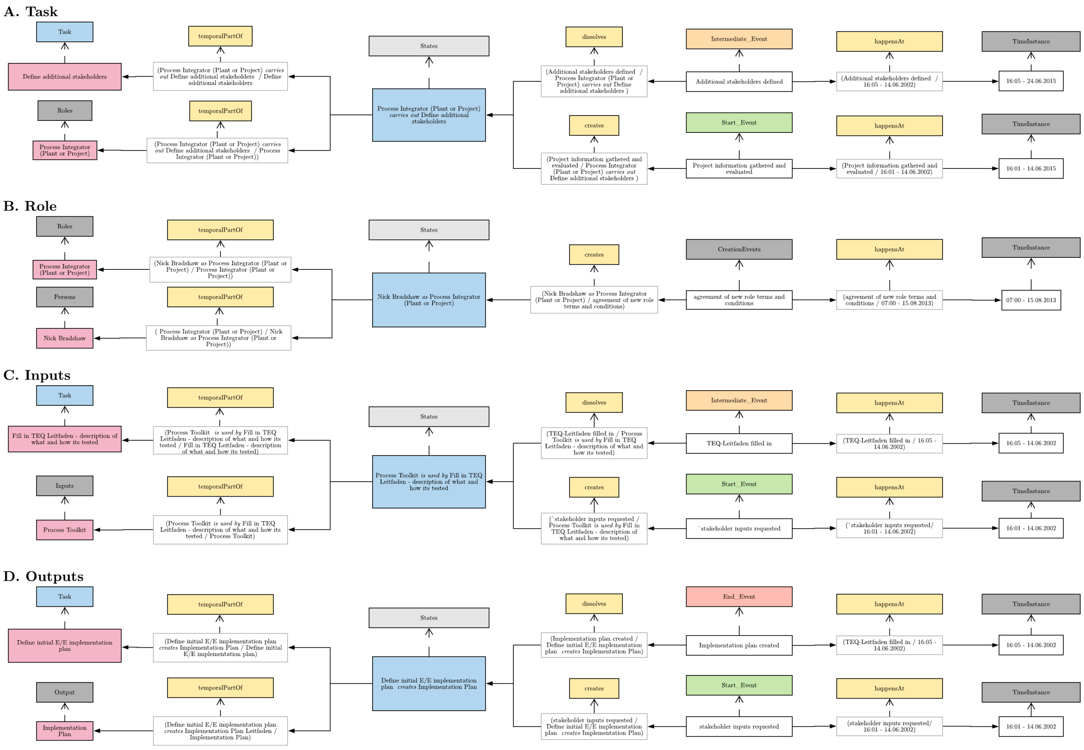


Figure 6-14: Instance examples

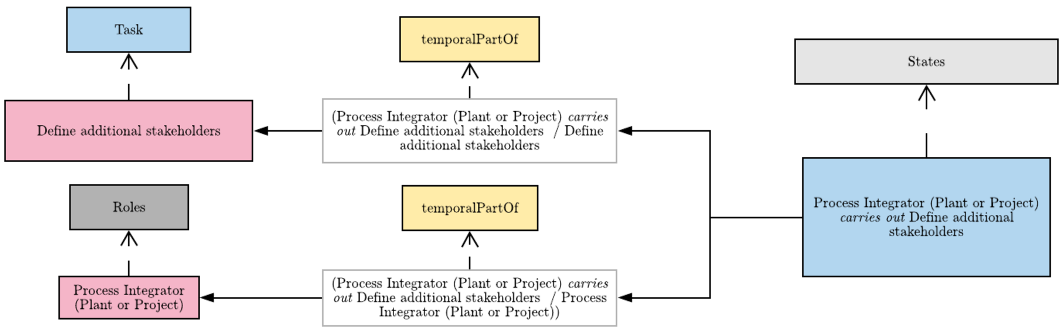


Figure 6-15: More detailed view without events
Show how the relationship between activities and roles is captured

6.5. Test and Evaluation

The verification of the ontology relates to the consistency, completeness and conciseness of the ontology created. **Consistency** of the model was addressed by use of a template (as described above) – each subprocess was broken down into consistent factors and instances represented by a common template. The use of such a standardised approach allowed to maximise consistency during the conceptualisation of the ontology. The repeat use of a standardised block template allowed to follow the same steps repeatedly to ensure that no accidental gaps or mistakes can occur.

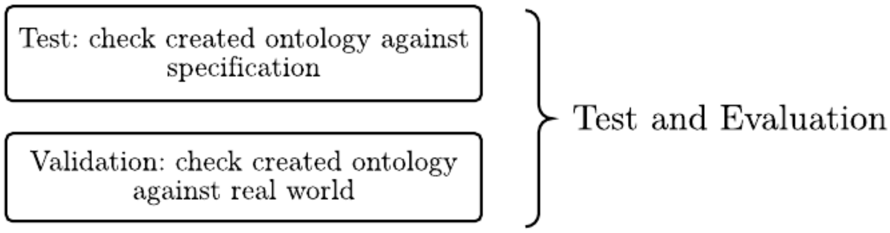


Figure 6-16: Test and evaluation

Completeness of the ontology was assessed against the scenario template: the ontology was reviewed, and it was ensured that all tasks, roles, inputs, outputs and other pre-defined scenario template elements were included. Not relevant aspects of the scenario template (such as legal norms) had been excluded before the conceptualisation stage, thus limited the scenario template to all relevant items. Throughout the conceptualisation of the ontology, the scenario template and the CQ were used to guide the creation of the ontology, thus providing repeated internal control loops. The **conciseness** of the ontology was continuously monitored during the conceptualisation stage – each ontology element was scrutinised for correct elements and all unnecessary parts were discarded. In summary, the careful design of class diagrams and iterative approach during the conceptualisation phase were aimed to allow easier verification of the model and to identify problems with conciseness, completeness or consistency early on.

The validation of the 4D ontology uses the previously created competency questions (Table 6-5). If the 4D ontology was implemented with a programming language, the validation would be based on a written query corresponding to a CQ. However, in this context, validation was undertaken using a visual assessment method, as shown in Figure 6-17. For each CQ, the ontology was manually reviewed to see if the question has been answered. The possible answers in this context were ‘yes’, ‘ok’ or ‘no’ (Brusa *et al.*, 2008) see Figure 6-17 for an example. In the example, the visual assessment of the competency question *Can you determine what role carried out an instance of the activity?* is shown. The ontology can answer this question by creating the relationship between the role (highlighted in yellow) with the individual tasks/instances of the activity (shown in pink, green and purple to demonstrate different tasks). The same visual assessment was carried out for all 16 selected CQs. Table 6-5 summarises the validation assessment. This allows to calculate a CQ confidence degree, as follows:

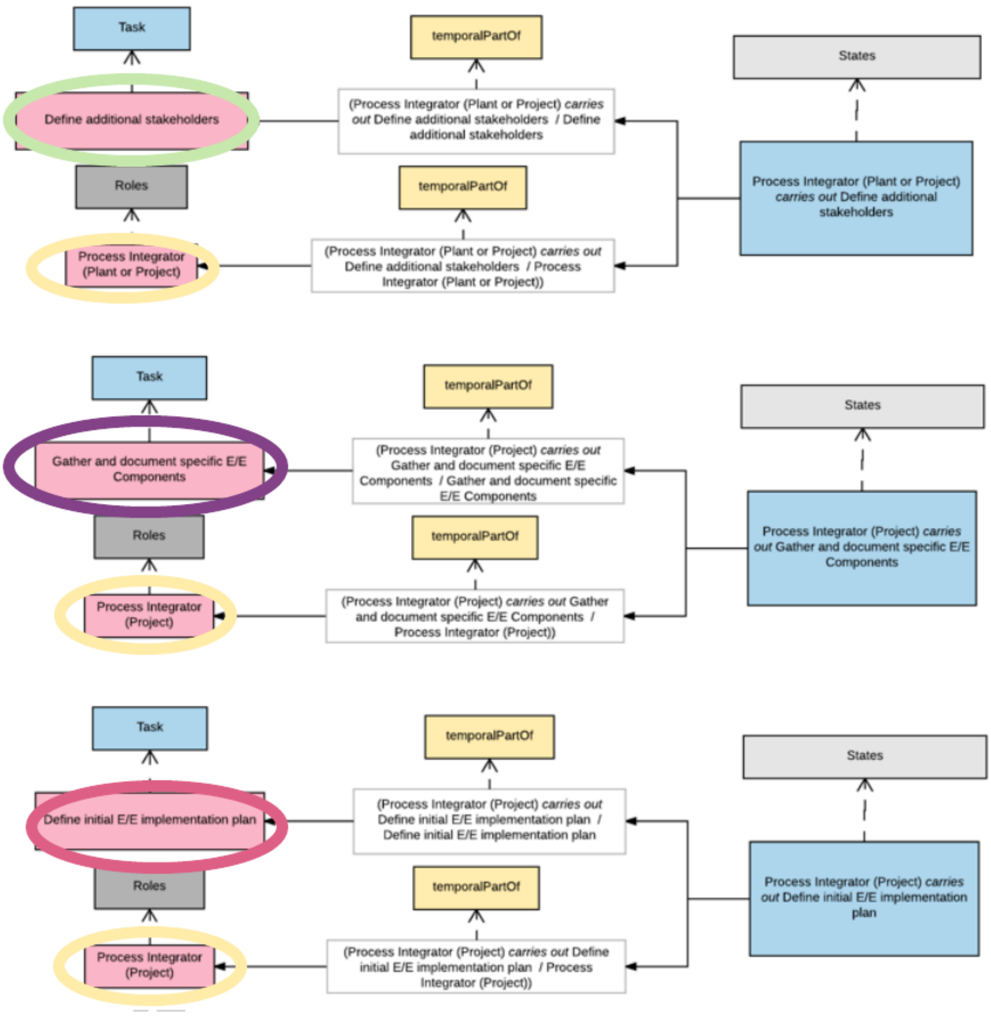


Figure 6-17: Example of visual CQ validation:
Visual assessment shows that ontology creates relationship between the role (highlighted in yellow) and its different tasks/instances (pink, green, purple to demonstrate different tasks) – therefore this ontology can answer the set-out competency question.

Activity based competency questions	Assessment	score
1. Are the process / sub-process resources clearly defined?	yes	1
a. What resources are required at a certain point of time in order to carry out an activity?	yes	1
i.What tools (SW / HW) are required?	yes	1
ii. What man power / job roles are required?	yes	1
2. Is the process / sub-process goal clearly defined?	maybe	0.5
a. What activities have to be completed in order to achieve the process goal?	maybe	0.5
i. What is the activity sequence?	yes	1
ii. How many activities in each process?	yes	1
iii. How can you determine that an activity is completed?	maybe	0.5
iv. What is the activity input?	yes	1
v. What is the activity output?	yes	1
3. Is the process / sub-process execution time clearly defined?	yes	1
a. Is the activity cycle time defined?	yes	1
4. What are the effects of unexpected (tool breakdown, or person missing etc.) events to the process / sub-process?	no	0
a. Are unexpected events defined in the model?	no	0

Organisational based competency questions	Assessment	Score
1. What activities must a role perform?	yes	1
a. Can you determine what role carried out an instance of the activity?	yes	1
2. Is the stakeholder able (pre occupied / trained) to perform an activity?	no	0
a. Can the relationship between the activity and the required training easily be established?	no	0
3. What process / sub-process goals cannot be achieved by a single stakeholder?	maybe	0.5
a. What sub process requires more than one role/stakeholder?	yes	1
b. What sub process requires only a single role?	yes	1
4. What process / sub-processes need other stake holders input?	yes	1
a. Does each process highlight inputs from other stakeholders?	yes	1
5. Is the process / sub process cross functional? (newly added to show process complexity)	yes	1
a. Are other departments involved (provide input, carry out an activity or receive an output)?	yes	1
6. Do all process stakeholders speak the same language?	no	0
a. How many languages are spoken?	no	0
b. Is the level of spoken and written communication easy to interpret?	yes	1
c. Is the process description clearly understandable so that the it can be followed?	yes	1

Table 6-5: Competency Question validation
Summary of outcome of visual assessment of CQ during validation

Activity based competency questions

$q = 11.5; \qquad n = 15; \qquad g = 0.77$

Organisational based competency questions

$q = 10.5; \qquad n = 15; \qquad g = 0.70$

In this research, one domain expert carried out the assessment, thus $e = 1$. As summarised in Table 6-5, the overall CQ confidence degree is calculated as 0.73 or 73%.

The creation of the ontology during this iteration identified important learning points. 4D ontologies as a method can feel very philosophical to someone without much experience and the lack of clear (step by step) guidance in the published literature can make it difficult for a relatively novice 4D modeller to create models. It was thus important to realise that the published literature can be used as a guide whilst allowing to develop a modeller's own method of the individual steps. Furthermore, it was seen that whilst the overall process model contained so much information and complexity it appeared difficult to capture, when segmented this then became tangible. It was also identified that once instances were defined, it was possible to scale them up and expand the model. After the business process hierarchy and relationships were created, it was possible to segment the instances. The learning points from previous iterations were important during this iteration: during RPD development it was shown that even when a process model is believed to be complete, further information and research (in second iteration) can subsequently not only create a BPMN but feedback to improve the RPD. An explanation could be that the creation of RPD and BPMN followed a rather unstructured path guided by experts/stakeholders. As a learning point from this, when faced with a complex new method like 4D ontologies the development of Competency Questions was identified as key. The creation of CQ allowed to set out requirements in advance, which then allowed to help to structure and guide the development of the 4D ontology artefact.

It is often believed that the use of ontologies could allow to capture higher quality models simply by applying their proposed modelling techniques, however the nature of 4D ontologies can make creating models rather inaccessible. Furthermore, most of the literature around 4D ontologies could be considered almost too philosophical for the use in a high throughput for industry.

Finally, it should be mentioned that this chapter only provides one possible validation of the created artefact. Another – however much more labour intense, expensive and time consuming approach that goes beyond the scope of this research – would be to fully implement a 4D ontology into a company's IT, allow a time period for this implementation to run and collect data and evaluate the model by the outputs and errors seen during this time frame.

6.6. Summary and conclusions

This chapter presents the final iteration within this research: the creation of an artefact of a business process sematic view using 4D ontologies using BORO with application of Design Science Research process. The artefact design used an approach based on a combination of available literate and allowed for structured development and evaluation using previously created organisational legacy data. This artefact provides the final level of the proposed framework, as shown in Figure 6-18.

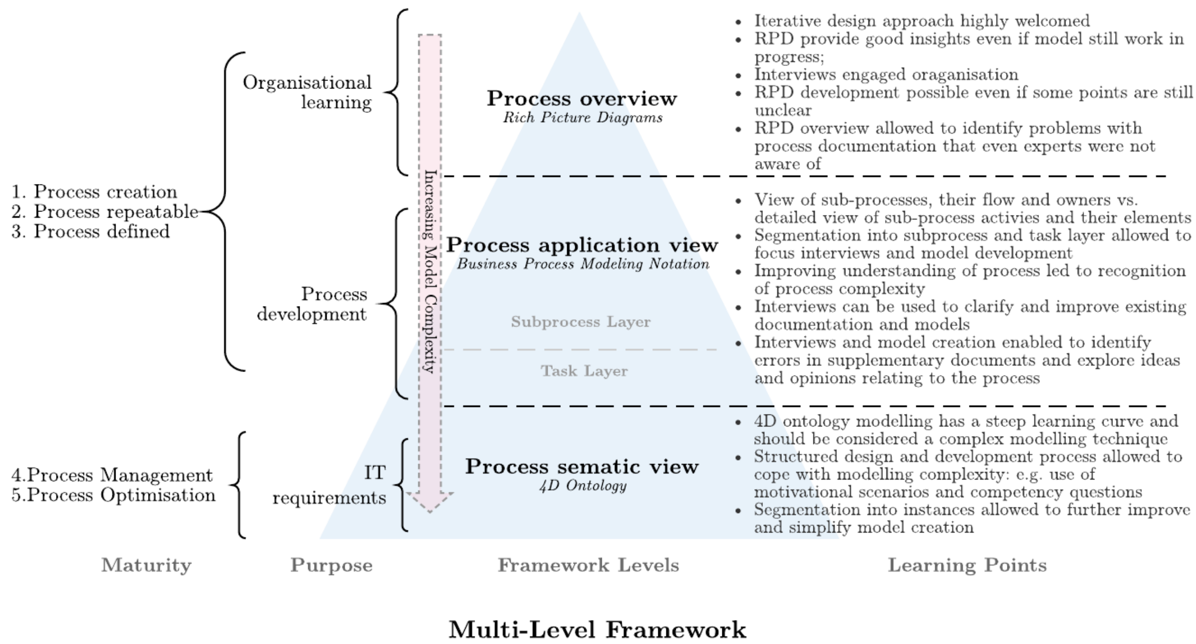


Figure 6-18: MLF after three iterations

The artefact design process was segmented into three steps (1) specification gathering, (2) ontology development and finally (3) test and evaluation. Specification gathering provided both motivational scenarios (process information) and Competency Question (CQ) (requirements for evaluation). Followed by the iterative ontology development process based in the BORO upper ontology. This process used the previously gathered requirements to define a class hierarchy, relationship between classes, events and finally process instances. This then led to the development of a 4D business process ontology. The ontology was tested as part of is development process, as the requirements are used to directly create each element of the ontology. The CQs were then used to evaluate the ontology based on how confidently it answered them. A graphical validation approach was used for this iteration.

This final iteration, again, identified key learning points:

- the combination of motivational scenarios and competency questions allowed to focus and guide the development of an artefact using a technique that can be difficult to grasp initially. This very guided approach was in contrast to the methods used in previous iterations – and whilst some of the strengths of RPD and BPMN arose from having an open approach and were able to identify problematic areas that were not even known of before the research started, it might be beneficial to take a more targeted approach for those models as well
- the benefits of segmentation of a process were identified as critical in being able to understand, model and capture a complex process with a multitude of information. This mirrors the learning from previous iterations where segmentation into production and planning (RPD) or process and activities/tasks (BPMN) was key to be able to understand the cross functional process better.

Chapter 7. Conclusion

7.1. Research summary

Today, business process are more complex than ever before and often span departments, companies and even countries (Hammer, 1990; Root, 1994; Letsholo, Chioasca and Zhao, 2012; Alotaibi and Liu, 2017). MNCs promote "best practice" working and its documentation using business processes (Smelser and Baltes, 2001), allowing them to increase productivity and remain cost effective. This also ensures that their quality standards are maintained. Business process models used within industry are designed to capture workflow to improve organisation understating, quality and lowering cost (DaSilva and Trkman, 2014). However, there is not only one correct view of any business process and thus not only one correct way to model it. Different modelling techniques offer their individual advantages and disadvantages. Depending on what is required a different model might be more appropriate.

The segmentation of tasks and the globalisation of business processes have inherently contributed becoming more complex. Not only has it become more difficult capture this complexity (Pinggera *et al.*, 2015), but also made it more difficult to understand the modern business process. One can argue that both points are interlinked, i.e. the ability to capture and represent the process influences the way the organisation understands it. And not understanding the process has a direct impact on the process performance and ability for further improvement (Sweller, 1994; Laguna and Marklund, 2013; Claes *et al.*, 2015). In this research, it became evident that the applied processes were not designed with the end user in mind. The organisation would benefit more from the process if it would be represented in a manner that facilitates understanding. For an organisation to move into this direction of (automated) process optimisation there is a need for it to capture its models in a more innovative way. The application of ontologies allows this by capturing both the relationship between elements, and any relationship changes over time. This then allows to answer queries such as what is the effect when e.g. who carries out an activity, what specific activities does a role carry out, how this compared to a previous time point (or time points), what tool(s) are required to carry out these activities etc. The way the information is captured when ontologies are used, is based on certain scenarios or situations of interests. The use of ontologies allows to use a 'language' that can be used to build a framework for IT to subsequently implement and build databases around it (Guizzardi, 2005; West, 2009; de Cesare and Geerts, 2012). The use of IT language and implementation is then the next step to use business intelligence tools not only to undertake analysis of the available information, but also to make predictive statements (Dijkman, Rosa and Reijers, 2012). However, it is also conceivable that rather complex modelling techniques such as ontologies might not create the most appropriate model of a process if a more general overview or focus on specific tasks and their flow is required. This research provided a framework that contributes to an organisation's knowledge sharing and considers different modelling languages for different people and their roles as well as different levels of process abstraction. The objectives as set out in chapter 1 are summarised here:

(1) Perform a critical literature review in order to identify suitable modelling techniques that cover all maturity levels and organisational purposes and use this as a basis to propose a framework

(2) Capture process based organisational data of one selected cross-functional process currently deployed within the research setting

(3) Create and validate the framework upper level, the process overview, by modelling the selected business process using Rich Picture Diagrams

(4) Create and validate the framework mid-level, application view, by modelling the selected business process using Business Process Model Notation

(5) Create and validate the framework lower level, semantic view, by modelling the business process using 4D ontologies

In achieving this aim and objectives, Chapter 2 reviewed the literature of business processes and business process models. Different modelling techniques were reviewed in the context of model maturity and organisational purpose to identify techniques that best suit the framework. Chapter 3 outlined the methodology used for this research and how Design Science Research methodology can provide an approach to solve the design problem. The DSR process was outlined as well as demonstrating how constructs will be created in the subsequent chapters. The iterative and incremental design approach is discussed and its benefits in the context of this research are highlighted.

Chapters 4, 5 and 6 showed the three iterations of the research. The first iteration described in Chapter 4 concentrated on capturing process based organisational legacy data of one selected cross-functional process and the creation of a process overview using Rich Picture Diagrams. A total of ten semi-structured were used in an iterative manner to create a final artefact. During the artefact development phase, initially the process planning, and production process were separated and modelled independently of each other. The final interviews allowed to combine them to create a full RPD. The Rich Picture Diagram (RPD) was used to capture and portray the researchers understanding, as suggested as part of the Soft System Methodology (Checkland and Scholes, 1990; Avison *et al.*, 1999; Checkland, 2000). Throughout the research, it became apparent during the conducted interviews that the RPDs were very well received and were also used as a way to present an overview of the process. The Fachteam Speaker (FT-S1) commented that the diagrams were

> "*easy to understand as compared to the excel sheets (….) It will be easier to communicate with employees*" (see Appendix for full transcripts)

and a Functional Specialist (FPS-P2) commented that

> "*it's [the RPD] excellent and it will be useful to communicate with the organisation with this sort of RPD*" (see Appendix for full transcripts).

RPD provided an ideal method of representing an integrated format, a combination of both diagrams and textual description (Chandler and Sweller, 1991; Kirschner, 2002) and allowed the user to familiarises themselves with the topic, thus helping with the further process of more complex information (Kirschner, 2002; Paas *et al.*, 2011). RPDs could therefore be used more routinely throughout the organisation, especially in situations where complex information is presented and discussed, or when an overall process overview is required. Key learning points from this iteration as well as the created artefact itself fed directly into the subsequent iterations.

Chapter 5 build on the created RPD to create an application view of the business process using Business Process Modelling Notation (BPMN). 18 semi-structured interviews were conducted in the process of artefact creation.

The second iteration focused on the use of the Business Process Modelling Notation (BPMN), highlighting the process subprocess flow and the relationship between the subprocesses and its responsible roles (Garretson and Harmon, 2005; Cabanillas, Resinas and Ruiz-Cortés, 2011). This therefore allows the organisation to quickly access to information about who is responsible for these activities, as well as to have an overview on a more detailed level than the RPD. The use of BPM can therefore supplement the overview provided in an RPD and be used in situations where more detailed information is required. The results from the second iteration were not only used in the next iteration, but were also incorporated into the RPD artefact previously created to update and correct it. Key learning points were taken forward to the next iteration, when appropriate.

Chapter 6 describes the final iteration which introduced the concept of ontologies and was based on a BORO approach. Instead of interviews to assess these models, a different approach was chosen. The reason for this was that ontologies cannot be analysed as easily by an interviewee who is involved in the process but has no knowledge of ontologies – unlike simplified RPD or the industry standard BPMN. Motivational scenarios were used to create competency questions, which can be used to guide the model development and subsequently used to assess whether the created ontology had correctly captured the process. The legacy data and information gathered in the previous iteration was important during the build of this artefact. The actual modelling process was guided by the literature and with the competency questions in mind. In this research, a visual validation of CQs was used – for each of the CQs set out, the ontology was visually assessed and then decided whether it answers the question. As this research focussed on the ability to build a 4D ontology in the described research environment, a validation that would require full implementation of the artefact into IT and validation of its performance was beyond the scope of what was achievable during this research.

The final multi-level framework is shown in Figure 7-1 and provides a summary of the maturity levels and organisational purposes addressed in this research. The key learning points discussed during each iteration are also summarised.

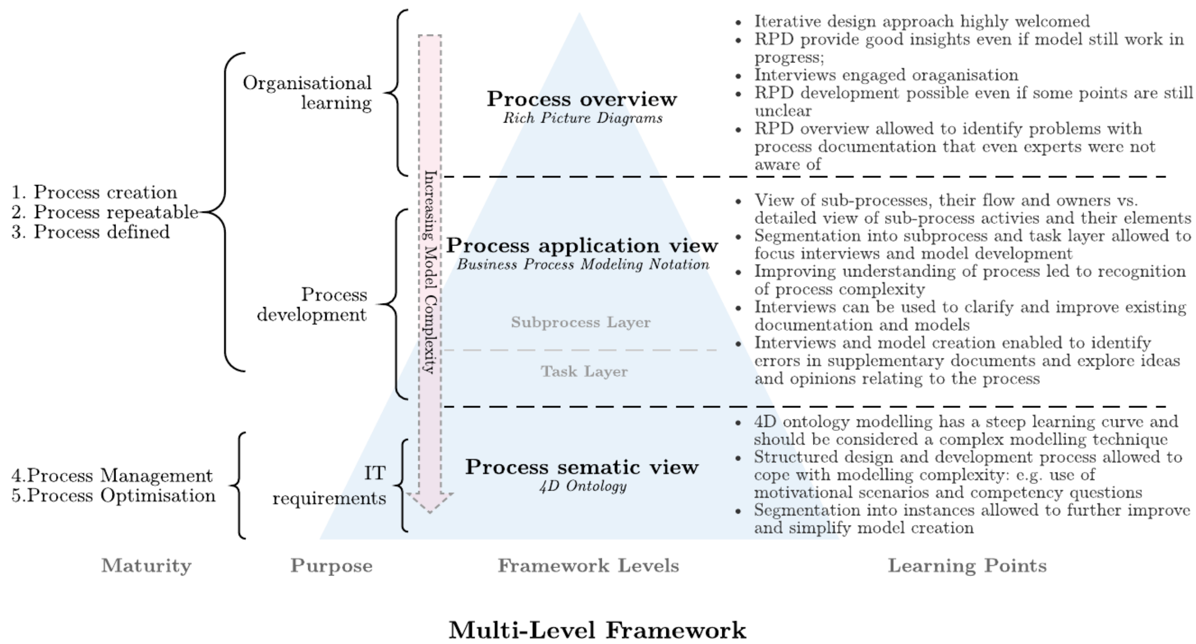


Figure 7-1: Final proposed MLF

7.2. Research contribution and conclusions

The Design Science Research product classification categorises research contributions – this research contribution mainly consists of instantiations and one method. Overall, the major contribution of this research is a novel multi-level framework which can provide an organisation with a structured approach to model its business process to span multiple process maturities and organisational purposes. This framework can be applied to different business processes and research environments. In more detail, the main research contributions can be broken down into:

- Multi-level framework (MLF) (**method**): creation of framework that provides sequential steps to follow to provide several abstract views of a process. The framework creation is described in detail allowing it to be generalised by other researchers. The MLF demonstrates that the models can add different perspectives of the same process that complement each other; whilst they build on each other, they focus on specific, different aspects of the same process thus allowing the researcher's (and organisation's) process knowledge to grow through the MLF creation process itself. Furthermore, the MLF supports a continued a discussion about which appropriate process modelling techniques organisations should choose, based on what purpose or maturity level they are looking to achieve; it also provides a reminder of how different modelling techniques can be used to portray certain aspects. Stakeholder input and maintaining close links to industry were emphasised throughout the creation process. In summary, the MLF demonstrates how three individual models – each of the models was created by rigorous application of approaches described in the literature provide a 'real world' representation of one business process, the *combination* of the models provides additional value that is not captured by any of the models on their own. The design process is represented in a manner that provides a lot of detail with the hope that this allows other modellers to learn and follow the steps of the creation and could therefore be used as a benchmark to improve further work. One that that is not considered is that each modeller will still need to be proficient in these three different techniques, which may not be practical. My experience within this specific research environment was that none of these techniques were already known within the business setting, let alone understood well enough to be used for modelling. One of the ideas of the MLF is that it uses techniques that build on each other to help the modeller ease into the process, though this is hypothetical – and how to best select complementing methods that enable such learning might be an interesting future research topic in itself. The models also benefitted from the fact that the organisational business process had already being captured, although the organisation appeared to struggle with interpretation of this; however it was possible to use what was available in the work towards the creation of the final models. Without any already available captured processes, it could be argued that the creation process would have been more time extensive and potentially of lesser quality. Finally, it's important to consider that in the future, making changes to the process would mean that not just one but all three models would have to be updated for the MLF to be correct, thus potentially adding further workload.

- Introduction of RPD technique (**instantiation**): to a production environment and demonstrating its feasibility to build an artefact that is accepted and highly recommended by involved stakeholders. The artefact provides an overview of the process that is usually not captured by the existing process documentation and allowed stakeholders to become more involved with the concept of business process modelling using a method not commonly used. The RPD provides a simple way (i.e., not restricted by syntax) of capturing the basic process but additionally an informal way of engaging with the organisation. This allowed the researcher to choose how they capture the process or even (such as was done here) work together with interviewees and allow them to actively draw diagrams during the interview. Those can be then later formalised electronically to form the basis for the next interview. One downside of this process is that it is time-consuming and – unlike with other, more formal modelling techniques – it can sometimes appear not clear how the final product has been improved. These are considerations that would make the routine use of RPD within organisations more difficult, however they have not been problematic during this research. Importantly, RPD can be easily used by novice modellers, i.e. there is no syntax to learn and was easily understood by the interviewed subjects as mentioned by the Fact Team Speaker: "(…) *it's easy to understand as compared to the excel sheets. (…) It will be easier to communicate with employees"* (FT-S1 / Fact Team Speaker). This allowed the RPD to be used as part of a more natural discussion of complex ideas surrounding the process. Furthermore, the "free flowing nature" allows it to be very flexible and it appears that this method can be used across many environments, in a small group or in a smaller setting or online (though they must be happy to use the right tools or software and they must be familiar with using them). One could argue that it is not necessary to use RPDs and that simpler process diagrams may be used instead, though irrespective of nomenclature it is the design process and "spirit" of creating and displaying a process as well as how it interacts with the organisation that is important and defines this type of modelling technique. There is no clear definition of when a process diagram fulfils the criteria to be considered an RPD, and some RPDs can seem simplified; the amount of detail required is different in each individual circumstance: there is no minimum or maximum requirement, it is, rather, the process and interaction with the environment to create an RPD that serves the required purpose that is important. RPD can be considered a lightweight method allowed for an unstructured approach, as it has no strictly defined syntax. This allowed for a lot of flexibility in the early stages and let me choose the tools I felt most comfortable with. Monk and Howard discuss this as one the advantages of RPD: it is quick to learn and therefore easy to apply within an organisation (Monk and Howard, 1998; Bjerke, 2008). However, there is an ongoing debate as to whether its lack of syntax might counterintuitively make it more difficult to use and to understand (Berg, 2013). I felt that applying RPD to this research, along with my background in UML and BPMN and my professional experience, provided an uncomplicated approach that was simple to use in my research environment. It allowed the interviewee to sketch answers to my questions, and also me to add to it throughout. However, it should not be underestimated how much time it took to go over the diagrams that were created during the initial interviews and to create the electronic versions, which was a lot longer that initially anticipated. The final difficulty for the use of RPDs was how and where to start the modelling process and the uncertainty what precise tools to use, similar problems have been encountered by others (Berg, 2013).

- 4D ontology model development process (**method**): literature-based selection of aspects required to structure the development of 4D ontologies, providing a step-by step approach to this research in the anticipation that this might be more easily followed by other researchers in different situations. The in-depth documentation of the development of the 4D ontologies hopefully also can be used as part of validation by others reading this research as it gives a thorough description of the creation of motivational scenarios and Competency Questions. This research aims to provide a more structured approach which others can access, follow and build on. Whilst there is a breadth of research using 4D modelling published, there often were only minimal details about how to exactly address 4D modelling (where to start, tools, etc). The description of my approach to development of 4D ontologies might allow other researchers to follow how I interpreted and applied the method. Soares and Fonseca (Soares and Fonseca, 2011) state there is a lack of guidance when it comes to the creation of ontological models and consider the creation process an art form. I used a combination of approaches based on literature: I used the overall method for capturing organisational data and transforming it into ontologies and ensuring they meet the original specifications based on work published by Bursa (Brusa *et al.*, 2008). This was then adapted to fit within DSRM process (specification gathering, artifact development and test and evaluation) to help with the conceptualisation of the process and made it easier for me to understand and start identifying what is missing. Models from previous iteration were then used to create ontology specifications. The CQ questions were based on Grüninger and Fox's approach (Grüninger *et al.*, 1995) providing a straightforward way for me to take learning from the first two iterations to create the CQ. One thing that might create difficulties if someone only used this method to create 4D ontologies is that they would be lacking the extensive work that was carries out in the first two iterations, in which process knowledge was created on which these specifications are based on. Without this previous work one would have to rely on other techniques to create this knowledge, though I cannot say how this would impact this stage.

Having created the motivational scenarios rely on helped me during the ontology modelling process, which in my view gave me structure and provided specifications that I could work off when modelling each activity.

The design process is transparent and other researchers can use it to compare to their designs at different stages; the representation of the creation process of 4D ontology in this thesis could allow those who are not familiar with the modelling technique to follow the rationale and evaluate and appraise the models – however, the use of the proposed methodology by others has not been assessed as part of this research. The use of DSRM in this research, it is argued, allowed a structure that can be followed to create the 4D ontology. However, whilst this research shows how 4D can be used for one selected business process, it was far from an intuitive modelling technique and the creation of 4D ontologies ought to be more clearly defined which would allow for it to become more accessible and used more widely outside of an academic setting.

- 4D ontology model of business process (**instantiation**): using the upper-level ontology, BORO, a 4D business process ontology was introduced, and segmented instances of each of its element (e.g., Tasks, Roles, and Inputs) modelled. The definition of the 4D business process ontology (lower-level ontology) provides a basis which can be expanded and learned from. The process that was used to create lower-level ontology, although complex in an operational sense (it has many reoccurring elements), it has a limited number of actual elements, such a measure of each instance. It is unclear how it would perform when extending it, although it would appear not be difficult this is something that has not been studied. However – at this stage – before the proposed approach is used to implement an IT solution, these models remain only theoretical and therefore difficult to evaluate its overall performance and impact. Certain shortcomings and/or difficulties might only become apparent when they are put to test during implementation. This is a limitation that might be shared amongst many (theoretical) modelling approaches.

The exact business needs and the level of understanding of the environment should be considered when selecting which level from the Multi-Layer Framework (MLF) is most appropriate to be used. The understanding of the different levels available to represent a process can help in having a structured approach which results in models which are correct and complete, whilst also being able to be put into the wider context. The use of an MLF allows a process to be represented at different levels, selecting the appropriate process model for each individual situation or organisational need. Whilst it is not necessary to provide process models at each of levels, it is important to understand that each process can be modelled at different levels of the MLF depending on the current situation or question. The MLF is therefore a more flexible framework in which each process can be represented in various ways rather than being only captured in one fixed form such as a table (Excel sheet). Practical limitations with regards to available time, resources (including individual knowledge of process modelling) and cost will apply. It is difficult to judge how such an approach would be applied and adopted within an organisation; since throughout the experience for this research, I have only once worked within a team that was fully process driven. That means they fully defined their processes, reviewed their performance periodically and made changes to it. While I have encountered many departments, who have confidence in their processes and process-driven approach, I have not seen any evidence of how this was reflected in their day-to-day practice. This makes it difficult to judge how the proposed framework would be adopted within an organisation which believes it already is process driven and might not see problems which were discussed and therefore sees no need (or does not understand the need) its benefits. However, this research has provided a structured approach for the use of different business process models to improve organisational understanding and communication.

The value of DRSM in this research setting was that it primarily provided a structure for how to conduct research within this setting. DSRM provides a structured and focussed approach, which allows not only others to follow it but also critically appraise how the process was carried out and the value of the artifacts that are presented. The methodology also allowed enough freedom for the researcher to choose several design approaches that suite the problem and its objectives, in this case the overall Iterative and Incremental Design approach, and within each iteration individual design approaches were selected. The combination of theory and practice to address a problem was seen as being particularly suitable for this research in allowing the theory to be applied within the problem setting and supporting the use of literature to identify the most suitable modelling technique and approach for each iteration. In addition, the use of DSRM ensured that part of the artefact design was to address test and validation before the artefact was actually built.

The MLF's value needs to also be considered from two aspects: in research terms but also organisational practice terms. From a research perspective, the MLF demonstrated the creation of models that fulfil different criteria set out by process maturity levels and organisational purposes. The MLF provides a transparent and rigorous overview of the creation of the different models within an organisational setting. It creates a reference for other researchers interested in business process modelling and how models of one cross-functional busines process can complement each other and build on each other. However, the MLF remains a theoretical basis that requires implementation within organisations to actually reach a certain maturity level within that organisation. The MLF shows that there is no 'one size fits all' solution when it comes to modelling a business process – there is no single method that an organisation can choose that will span all purposes and maturity levels. Whilst the lack of one universal solution for business process modelling might be more widely recognised, the MLF offers a first discussion where one process is modelled using several approaches to address different organisational purposes and maturity levels, and to discuss how the methods can complement each other.

An ongoing discussion about the benefits, strengths and limitations of different modelling techniques remains important. It is, however, equally important to highlight how the techniques can complement each other and can be used in combination rather than in isolation as they can capture different aspects of a single process. Furthermore, this research emphasises the importance of creating models in a transparent manner as there is a lack of detail of *how* to model a process and how to assess the quality of each model that is created. There is also scope for further in-depth research on how best to integrate existing and new models in an organisation.

The MLF's value in organisational practice terms is that is suggests that using different models for the same process can help to address different processes, and that one model per process might be insufficient. The MLF also allows an organisation with limited modelling skills (e.g., without dedicated departments) to follow this – or a simpler approach – to create higher quality models. Business process modelling needs to be well established within an organisation to be of value – whilst many organisations have some business process program in place, at the operational level it is often not implemented as implementation requires capacity and organisational acceptance (Srinivasan and Kurey, 2014).

Ultimately, an important question is how the academic research and organisational practice terms of business processes can be more closely linked: are organisations ready (or able) to apply new practices and is there enough organisational 'buy-in' – resources, cost, development – to integrate the MLF into their practice?

7.3. Limitations

Although this research has made a number of significant contributions, it is important to highlight some limitations and challenges encountered during this research.

- During the development of RPD, the conducted interviews have no record except for produced diagrams with annotations by the interviewed stakeholders. This might mean a potential loss of data that was not captured by the drawings and has not been identified by the research at the point of interview. Whilst audio-recordings would have been possible, it was felt at the time that they would insufficiently capture the process as the focus was on the creation of drawings.

Whilst the changes drawn onto the RPD were used in future versions of the RPD, there was no formalised analysis of the added drawings. To assess and analyse this more formally in the future, it might have been possible to include video recordings or electronic devices which track drawings – this would have allowed to review the interviews at later stage and follow the changing drawings and developing RPD in more detail. However, at this stage it is impossible to comment whether the interviewees would have felt at ease with such recordings.

- Within the literature it is common to validate ontologies using CQs. In order to truly assess and understand its utility, ideally validation would include an implementation of the artefact into its desired environment. CQs are commonly used partially due to the fact that most use of ontologies to date remains theoretical. In order to implement the ontology one not only need the models but would have to be able (1) capture data, that is creating a data model on the ontological model and access to a data set. (2) the data would have to be analysed and a performance matrix would have to be established so that the company can assess the results. Although all this would be theoretically possible it would require more time, and a much higher involvement from the production plant as well as use of more access to their data etc. It might also be possible for skilled modellers to create ontologies without a formalised creation of CQs – but the process of motivational scenario setting, and CQ creation allows for a more formalised and structured approach to 4D ontology creation. You could also argue that without asking the relevant question, the ontology creation might not model this aspect and could be therefore at risk of being incomplete. However, on the other side it can be argued that the creation of CQs limits the ontology to answer these questions only – ideally further CQs should be considered, added and included during the modelling process.

- One could argue whether competency questions and motivational scenarios are needed if business processes already exist, whether in form of spreadsheets or other process representation. For example, Daga *et al* used business legacy data such as process diagrams and other available documentation to directly create ontologies (Daga *et al.*, 2005). For this research, the emphasis was not only on the *creation* of a 4D ontology, but also on a *structured* approach that would allow a thorough understanding of how to create the ontology and how the process of creation compares to other modelling methods used. The use of motivational scenarios and the creation of CQs allowed focusing on the underlying situation and having signposts in the form of CQs. It can be compared to setting out the required specifications which the ontology needs to answer to be considered complete and correct.
- Unexpectedly the learning process of 4D ontologies and lack of detailed published guidance how to use this method with cross functional processes was a time-consuming task. As it was rather difficult to grasp some of the modelling concepts, it was therefore not possible to use the same interview-based approach during 4D ontology design as the earlier chapters allowed – it would have been not possible to find stakeholders with such in-depth knowledge of a new method to be interviewed. The time for visual evaluation itself was also not insignificant, as creating any automated analysis would have required a first full implementation of the ontology.
- Furthermore, this research could have compared the performance of different techniques against each and how the research environment reacts to them and which they prefer and what is easiest for them to maintain within their organisation. However, direct comparisons of modelling techniques are already in the published domain (Aguilar-Savén, 2004; Recker *et al.*, 2009; Tangkawarow

and Waworuntu, 2016), and therefore this was not further explored in this research but is something that could be further investigated in the future.

- One could argue that whilst this research was able to create a framework using IID, and whilst each level has been separately evaluated as well as building on each other, there has not been a formal validation of the entire framework. This is recognised as an area that was not studied and whilst scrutiny was applied at each level to validate the created models, the overall framework and its role during a full implementation into business was not explored in this research, however, is something that can be further investigated.
- Choosing the right tool to create the models has proven to be difficult as there was not one tool or software that could be used across the iterations. In addition, the limitation of what was available at university and at the organisation meant that more than once, completed models had to be remodelled. Also, it made it more difficult to share models with the organisation. As an example, the RPD was initial modelled using Curio (due to its availability and usability for a different operating system), then switched to Visio (Microsoft, 2013), software used by the company, which had its own learning curve. The same applied for BPM –Visual Paradigm (Visual Paradigm International, 2013) was used to capture models which meant the company only received printed / pictures of the process. For the 4D process ontologies initially Visual Paradigm (Visual Paradigm International, 2013) was used to create class diagrams, though the tool was initially very difficult to use and a lot simpler cross platform tool Lucidchart (Lucid Sofware Inc., 2016) was used in the end – this allowed for easier creation of models and sharing with others.

7.4. Further work

Whilst this research presents the multi-level framework as the final artefact that has addressed the initial problem, some interesting novel avenues and questions have been identified throughout. The future of business processes lies with business process innovation and the creation of predictive processes. The idea behind this concept is to use artificial intelligence to make predictions of the impact of changes on the overall process. In European production orientated environments, the term "Industry 4.0" has started to emerge to combine fields such as the use of big data, advanced analytics, augmented reality and advanced robotics. 4D ontologies could therefore be key in providing the big data component of Industry 4.0 in the future.

However, in the more tangible immediate future, some of the more interesting areas to focus research on might be:

- Application of ontological process design to other process modelling techniques and comparison with the iterative design approach using semi-structured interviews.
- Full Implementation of 4D business process ontologies into an organisation.
- Application of the multi-level framework to different processes to see how the framework performs – this could be either using different cross functional processes within the same plant, or ideally processes from a different background. This might allow to fine tune the modelling and create a more general approach how multi-level frameworks can be used to capture processes
- The incorporation of IT language with 4D ontology allowing to use formalised queries to validate new models; the use of IT is an important step towards true process optimisation (quantitative) rather than improvement (qualitative). This would allow to create IT solutions for business process optimisation and

integration with further business process innovation tools, such as statistical analysis and predictions.

- Creation of a software solution where available legacy data can be automatically transformed into either 4D ontologies or other business process models with the option to create higher or lower level process modes (based on the proposed multi-level framework) as required by the organisation, e.g. by exporting an overview RPD style process overview for certain situation and creating task or activities views in other circumstance.

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Appendix

This appendix is divided into three parts, the first part provides the available job description of some of the interviewees. Subsequently, the business process documentation currently used in the organisation (in excel sheet format) is included.

The second part refers to the documentation of the interviews: all diagrams annotated during the first iteration of the interviews is included as well as full transcripts of all the interviews for the second iteration is provided.

Finally, the third part of the appendix shows the complete evolution and creation of all Rich Picture Diagrams, Business Process Models and Ontology.

A. Role and business process documentation

I. Role descriptions

Brief description	[redacted] [redacted]

Duties		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					
	[redacted]					
	[redacted]					
[redacted]	[redacted]					
	[redacted]					

Duties		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]					
	[redacted]					
	[redacted]			X		
	[redacted]			X		
	[redacted]					
	[redacted]			X		
	[redacted]					
	[redacted]					
	[redacted]			X		
[redacted]	[redacted]				X	

Duties		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]				X	
	[redacted]					
	[redacted]			X		
	[redacted]			X		

T-E/E-Prozessintegrator

Name of the role:	T-E/E-Prozessintegrator
[redacted]	[redacted]

	[redacted] [redacted] [redacted] [redacted] [redacted] [redacted]

Duties:		Leading	Decision	Realization	Information	Support
[redacted]	[redacted]	x		x		
	[redacted]	x		x		

	[redacted]	x		x		
	[redacted]			x		
	[redacted]			x		
	[redacted]			x		
	[redacted]			x		
	[redacted]			x		
[redacted]	[redacted]					x
	[redacted]					x

	[redacted]					
	[redacted]					x
	[redacted]	x		x		
	[redacted]	x		x		
	[redacted]	x		x		
[redacted]	[redacted]		x	x		
	[redacted]	x		x	x	
	[redacted]		x			

	[redacted]					
	[redacted]	x		x		
	[redacted] [redacted]	x				
	[redacted]	x		x		x
	[redacted]	x				

	[redacted]	x		x		
	[redacted]	x		x		
	[redacted]	x		x		
[redacted]						

CoC in charge:	CoC E/E-Prozessplanung		
[redacted]		[redacted]	[redacted]
	[redacted] [redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

	[redacted]		
	[redacted] [redacted]	[redacted]	[redacted] [redacted]
	[redacted] [redacted] [redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
	[redacted] [redacted] [redacted]	[redacted]	
	[redacted] [redacted]	[redacted]	

	[redacted] [redacted]		
	[redacted] [redacted]	[redacted]	[redacted]
	[redacted] [redacted] [redacted]	[redacted]	[redacted]
	[redacted] [redacted]	[redacted]	[redacted]

<table>
<tr><td rowspan="3"></td><td></td><td></td><td>[redacted]</td></tr>
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II. Process descriptions

Process step ID	Process step	Typical duration (PT in h)
		[redacted]
02918910	Name a T-E/E process integrator for the product line	[redacted]
02918911	Conduct project management for E/E process planning	[redacted]
02918912	Gather and collect relevant information for project	[redacted]

Process step ID	Process step	Typical duration (PT in h)	
		[redacted]	
02918913	Agree and document necessities for E/E testing and commissioning	n. rel.	[redacted]
02918914	Influences on product: gather, collect and generate E/E requirements for testing and commissioning	n. rel.	[redacted]
02918915	Conduct economical project evaluation	n. rel.	[redacted]

Process step ID	Process step	Typical duration (PT in h)	
02918920	Integrate course of commissioning into equipment and frequency independently of plant and make plausible in plant (integration into commissioning and test stand)	[illegible]	[redacted]
02918921	Initially test and validate course of commissioning	[illegible]	[redacted]
02918922	Conduct intermediate approval FIZ7plant	[illegible]	[redacted]

Process step ID	Process step	Typical duration (PT in h)	
			[redacted]
02918923	ntegrate course of bringing into all ffected plants.		[redacted]
02918924	Validate Course of commissioning in all elevant plants		[redacted]
02918925	Conduct local problem analysis, documentation and controlling (PMP)		[redacted]

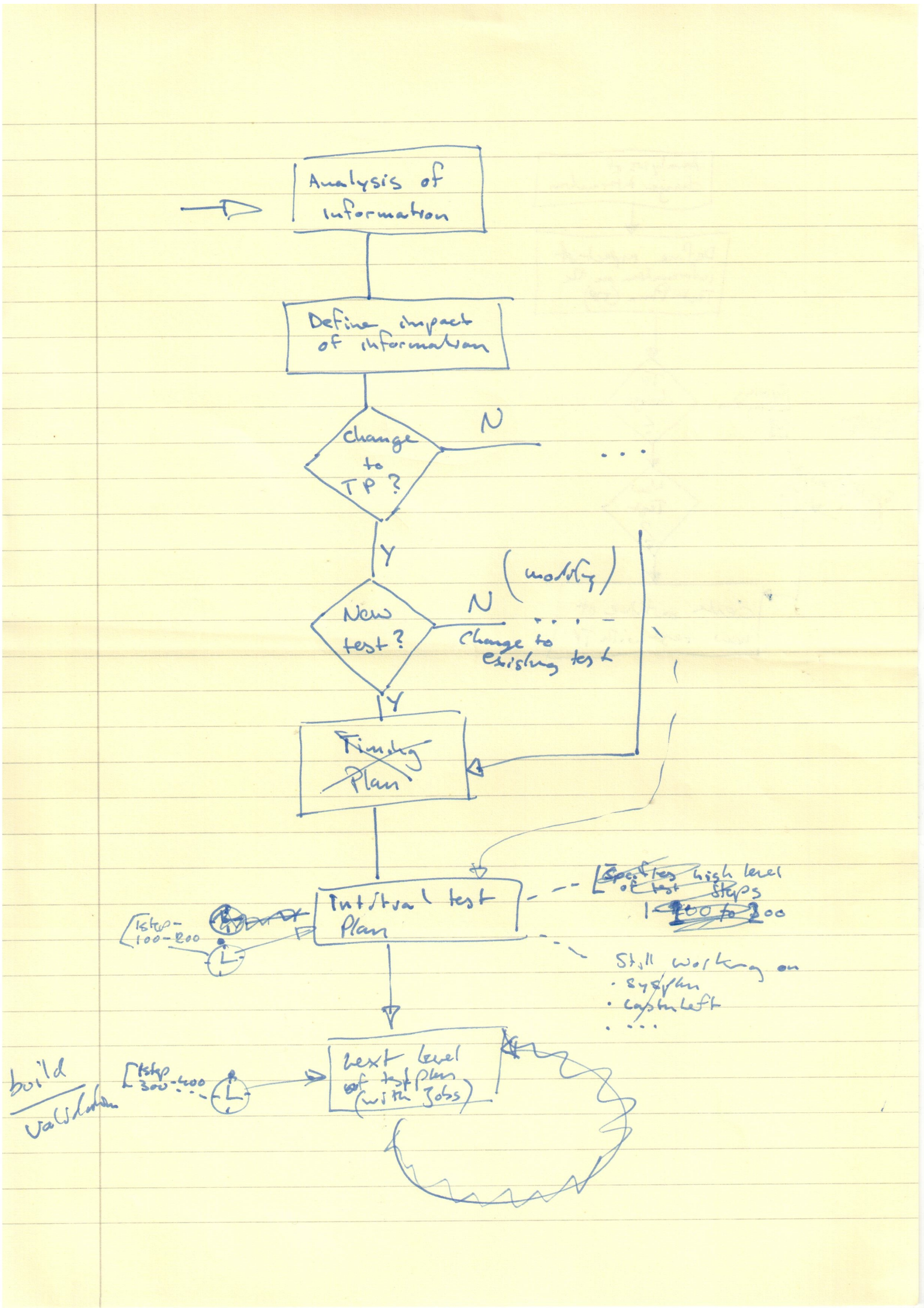
Process step ID	Process step	Typical duration (PT in h) [redacted]
0291892	ntegrate course of bringing into all ffected plants.	[redacted]
02918924	Validate Course of commissioning in all elevant plants.	[redacted]
02918925	Conduct local problem analysis, documentation and controlling (PMP)	[redacted]

Process step ID	Process step	
		[redacted]
02918926	Conduct cross-plant synchronization and overall problem solving (PMP)	[redacted]
02918927	Hand-over of course of commissioning to Construction	[redacted]

Process step	Conduct LeLe
[redacted]	[redacted]

B. Documentation of interviews

I. Interview questions: 1st interrelation



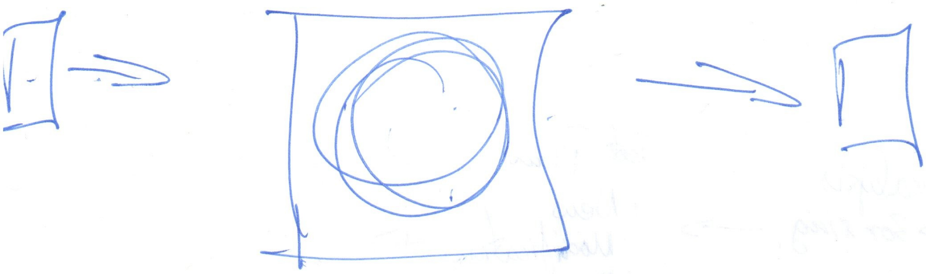
Analysis
→ Sorting → Test Plan
- New
- Modification
- None

→ Project
- Build phases affected
- I steps – DATA etc.

→ Specify initial test plan

Discussion with System specialist / Test stand specialist
→ Agree necessary changes to test system / process
→ Agree timing
→ ~~Design~~
→ Make the changes

Validation
DST → 8GBD jobs, results
Disconnection tests
Pre-series build



Tech

Info → Afo (gAMS) → Info → changes necessary to meet proj rqmt
Costs → Invest / FK prop / MK prop (per vehicle) one off

DMS → Proj Sup – ~~Anouncement~~ new
change to existing
End of proj

NAEL

→ ECP

→ CCB → ET → Determine ~~~~ 1step plan based on Vehicle build plan

~20 Days to SR

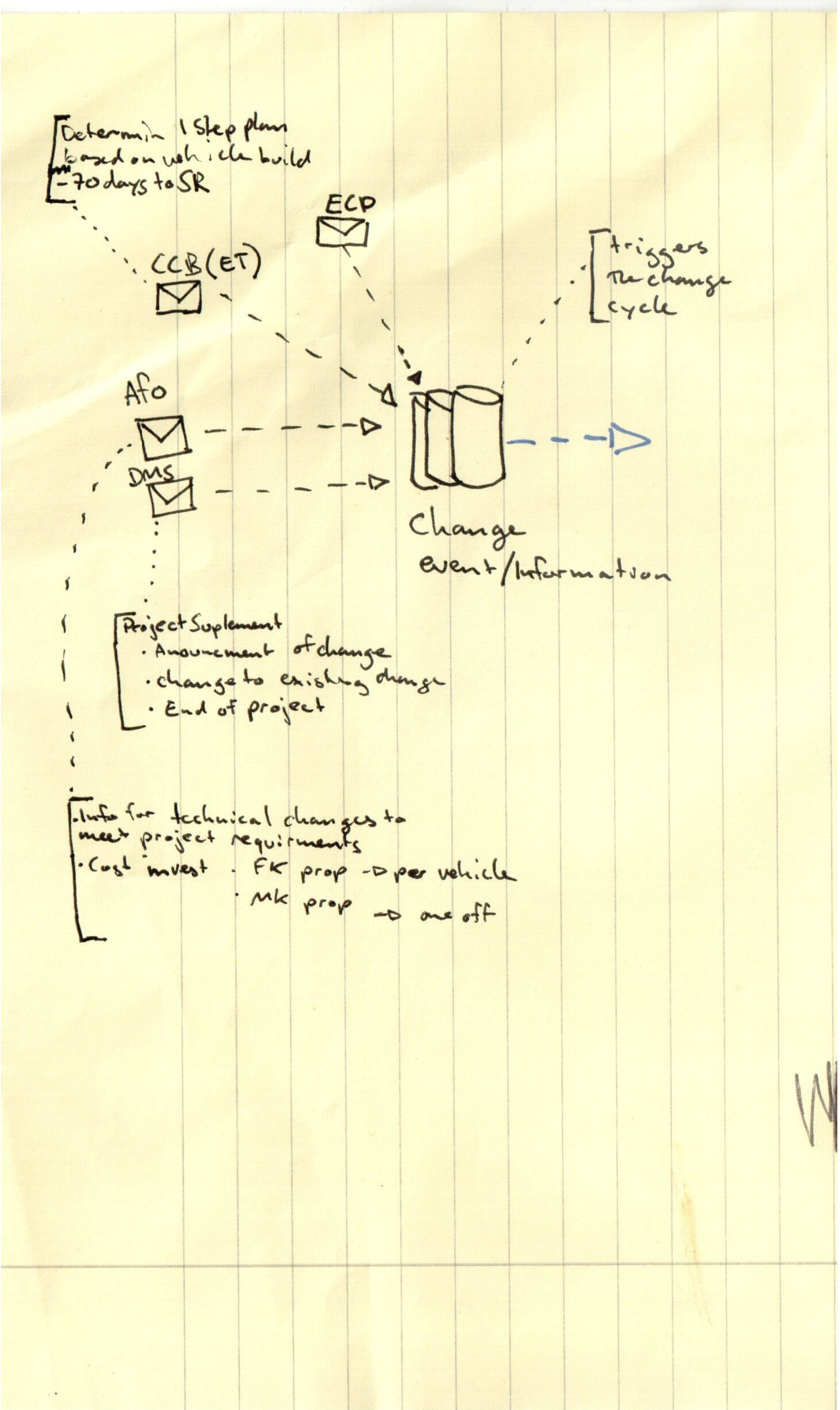
→ QC

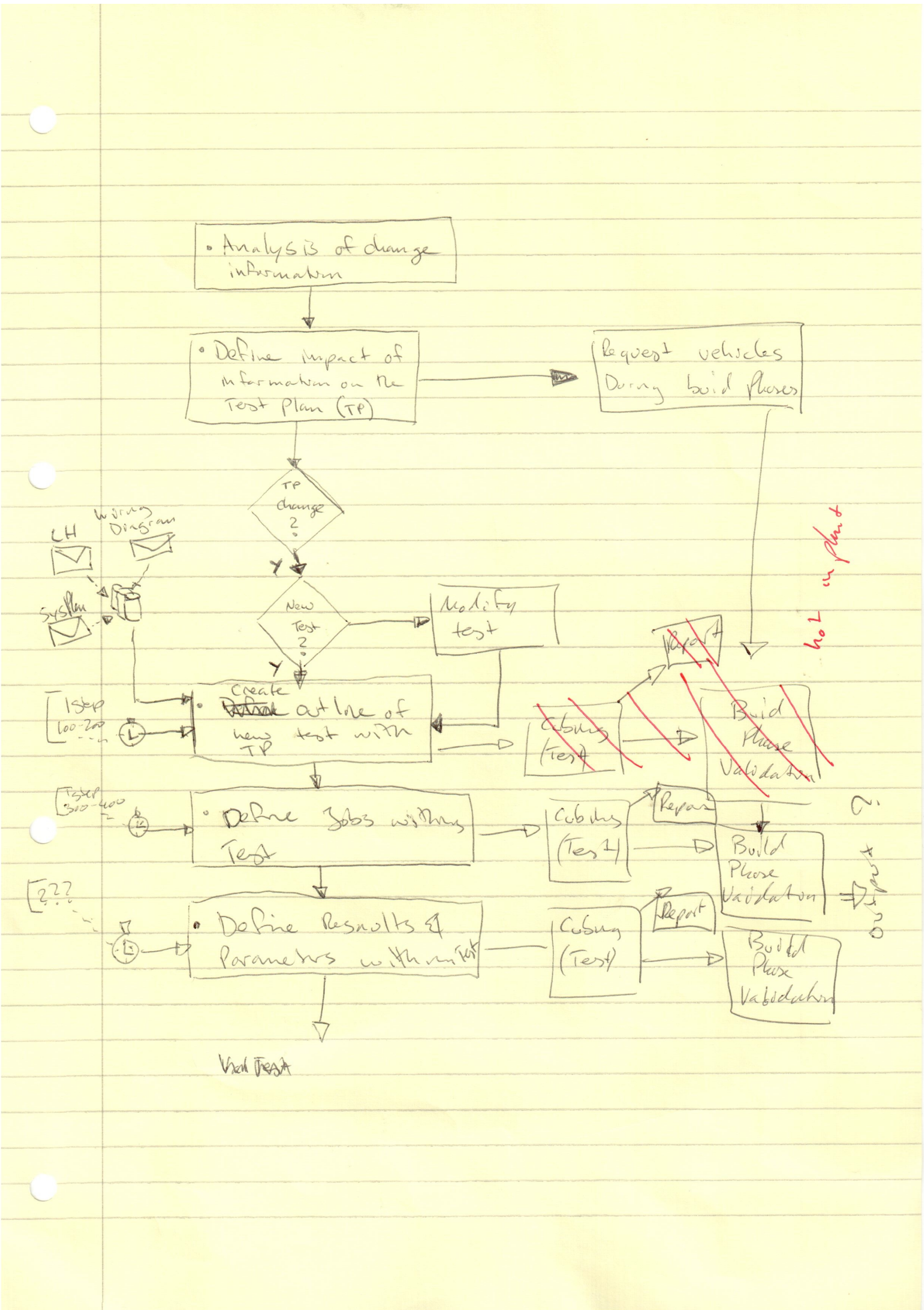
Interview with PP1

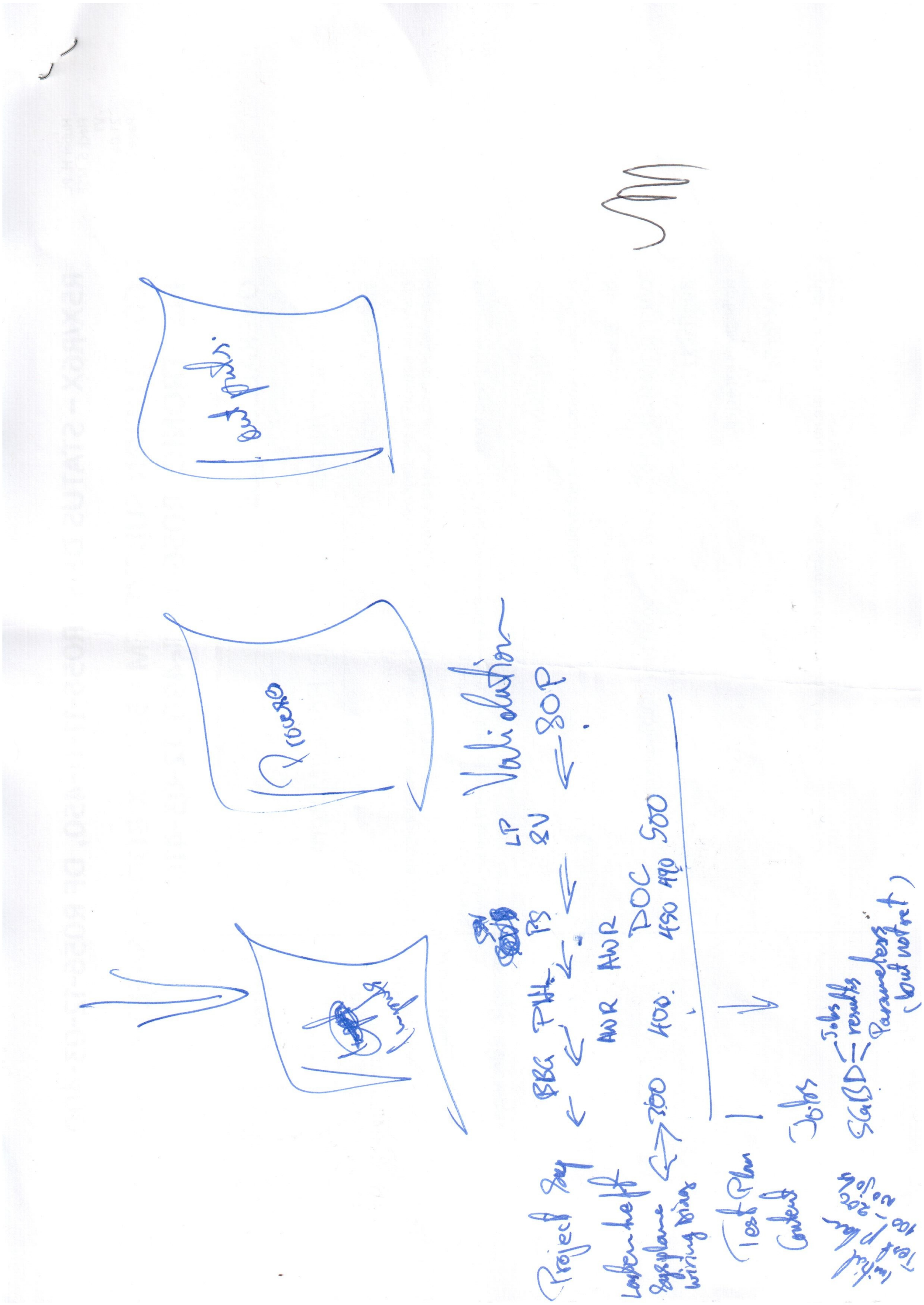
one hour on ~~the~~ how information / inputs trigger the change process. looked & defined the information flow at different stages and the communication at different levels / tiers of the project.

levels / tiers

| gams → NAEL → ET → ECP |


Determin 1 step plan based on vehicle build
-70 days to SR
ECP
CCB(ET)
triggers the change cycle
Afo
DMS
Change event/Information
Project Suplement
· Anouncement of change
· change to existing change
· End of project
· Info for technical changes to meet project requirements
· Cost invest · FK prop -▷ per vehicle
· MK prop -▷ one off


• Analysis of change information
• Define impact of information on the Test Plan (TP)
Request vehicles During build phases
TP change ?
New Test ?
Modify test
Create outline of new test with TP
• Define Jobs within Test
• Define Results & Parameters within Test
Build Phase Validation
Report
not in plant



II. Interview questions: 2nd interrelation

Role: Fact Team Speaker/ Process Specialist/ Functional Specialist

Person: FT-S1

Date: 29.08.2012

Can you summarize you job duties?

Planning for ECOS Test and as a Functional Specialist creating the test steps and the Process Specialist creating them to a sequence.

Have long have you been performing these duties?

Since 2008

Does this rich picture diagram make sense to you?

Yes it does and its easy to understand as compared to the excel sheets. The Production Planning process should also be shown in this manner. It will be easier to communicate with employees.

How is this process different to the vehicle build for the SBWE planning process?

Are you completely aware about the Process Sheets (9_1-9_2)?

No saw them recently and wanted to close them

How useful are these Process Sheets? (Why is that?)

Not useful at all should be depicted graphically. Its far too complicated

Do you understand the planning process of PEP and SBWE?

Certain steps such as BUZ Factor and INPA scripts was not sure who creates them or who is involved.

What is your role in the PEP and SBWE planning process?

Peter D. Stanner

Designs the tests for the vehicle during PEP

Are you aware that a Project/ Plant Functional Specialist exist?

No, didn't know the difference. Project FS is at Munich and Plant is at plant level.

How do plants communicate changes?

During SBWE they should communicate changes but they don't as they speak different languages (technically).

According to this person, the changes should be communicated but is not sure how they should be communicated.

During PEP, the FACT Team does this and there are no communication issues.

Across the organization how is this process sheet communicated? How do people involved in this process know their responsibility?

No one uses the sheet and the process is just learnt.

Do you think there can be improvements in the communication of these process sheets or process? What is your recommendation?

Graphically depicting this will be very useful.

Role: AK Member

Person: AK-P1

Date: 29.08.12

Can you please summarize your job duties in the AK?

As the group leader for Elec Process Planning, TI53 that I represent Oxford as a Plant. Oxford is the only place that builds L3. I represent that product also. Within the AK, are also leaders of the Facht Team. Worldwide group deal with Technical subjects. He deals with the Finish process and Rework.

Any other roles?

Disciplinary resp for associates in Oxford and for the work they carry out and the way they carry out.

How are you involved for PEP and SBWE?

For PEP, I am a Customer for the Process Integrator and the EE Integrator because they have to tailor the designed PEP process for Plant 0 to implement at Plant 34, they have to agree with me and my team.

For SBWE, it is different, potentially, my team may lead in SBWE project. All L3 projects are done in Oxford and we lead those projects

What is the role of the EE Integrator?

Implementation of all EE processes for the particular product line and the plants.

I.e. LU – for the overall governing processes for EE then the Integrator is in responsible for making sure they are implemented correctly within target plants. So the verification and validation T05, the software logistics processes TI-51, Logistics processes TO-4/TO-M.

EE Integrator is responsible for a product line at Plant 0 and the Target Plant. In the whole organization they have a partner at the plant.

The Process Integrator works within the EE Integrators team. There is the link from the PI to the EE Integrator.

How long have you been around?

I became the Group Leader in 2001. I took a 2 year break to take some time off for placement in Munich. As the FACHT Team since last year.

For the PEP who selects the Project Team?

The AK selects the team. The way those selection is done is through the FACHT Teams.

Have you had a look at the Process Sheets?

Yes

How is your comprehension of the Process Sheets?

I have made improvements to the Process Sheets in terms of the English/German translation.

Would it be right to say you have a role in 910?

Yes but as a customer. If the AK Group Leader selects a PI do other plants have an issue.

How do these steps vary from the SBWE Process?

So for this step, again within the FT for PI then the group leader responsible for the FT will select the guy who will lead the SBWE measure because they are cross product line.

In the Plant, I select the Process Integrator then the contact person for the Central Plant.

So would it be right to say that SBWE is more on a Plant level and whereas PEP is more on Central level?

In the past SBWE has been exclusively on a plant level, so you could have the same product in different plants with a different test plan because they have the individual integrators. But now, we have a central SBWE integrator, that then coordinate those tasks. So if we have product or a change in multiple plants then that FT will split it up and distribute it to the different Process integrators to then work on that subject. They then can share that information to make it one test plan.

How are changes communicated during SBWE?

It is to the department, to the group, TI-53 through the Process integrator. The PI is responsible for basically all product changes. So, from product line so SBWE project or running changes or emergency changes i.e. Jap Tsunami, Change of Suppliers is passed through the Process Integrator.

Are there any communication concerns that you would like to highlight in the EE Process Planning?

I actually like aspects of the multi language with proper nouns but it does not work well with verbs. Like Projekt Leiter. Or Pus and PLs.

Taking the German word makes the meaning easier or communication easier. But training must be provided.

What is the BUZ Factor?

That is a business analysis process, so they do a early phase project, minimum of 2 phases with different levels of granularity of info. Start of with a broad module description of what the customer functionality will be and how they would technically supply that and what would be the impact would be on the electrical test. What invest would we require. Its predominantly about the financial viability of a particular product. It is the early business assessments

Would the FT be assisting the PS and FS here?

PS and FS are members of the FACHT Team.

What is INPA script?

This is GUI for an app to be used during analysis or rework. It is a way of sending and receiving diag info to the vehicle without having the cumbersome test process. TP runs through the whole sequence whereas The tool set or the app allows individual diag commands, diag info. INPA is the GUI in the front of this so we can restrict access to the areas of the car to the Rework and Analysis People who perhaps haven't got the training yet.

Do you agree with the PEP and SBWE breaking up into two circles?

Within PEP it can also be Test steps revised, we can further development. Although PEP projects is for the major projects change. So at least there is 30% direct copy without serious modifications and then around up to 30% of new mods and changes.

Within, SBWE new developments are possible on new parts.

The focus tends to be in that new steps created for PEP and revision of steps for SBWE.

Do you think the initial factors would be there according to you in the RPD in SB/WE?

No there is not a difference in the process on block level. For ex, BUZ, it runs but not in such a large effect, so the BUZ is a huge process in PEP. So every dept/ every group involved in the development of the new product gets to input. The process runs exactly the same in SBWE but on a much smaller scale and a lot faster timescale. So for example you would only be given 24 hours make an assessment because it just base information about what the changes are about, about the major impact would be.

I have depicted the T-E/E Integrator here, before the handover to the plant. Which according to me ensures the implementation of the project documentation on the plant floor. Is that right according to you?

Well no because that is really the Process Integrator's role. The T-E/E Integrator covers the whole of the process through the Process Integrator and has other responsibilities as well such as the planning, I-Steps and the delivery of those, Customer Functionality from the T-Ressort side. So they get to cover the whole project, but not directly because they go through the Process Integrator.

How useful are these Process Sheets? Do you use these for training?

Only with the Process Integrator.

But according to you, are these communicated at all when it comes to new employees or new projects/ products?

Sorry I don't understand.

What I mean is when there are new projects/products or people involved are the process sheets used at all?

For new employees when they are not a PI, then no but we do show them the content to make them aware but as used as a training aid to explain what their role is then no.

So according to you how do people involved in this process know their responsibility

Because I describe it to them.

So as far as the RPD goes, other than the PEP and the SBWE being similar, so if you were to depict the T-E/E Integrator where would you place him within this process?

I would place him as a contact to the PI because that is his contact. It Is not steered in this way which seems to be very much through the test implementation that can be misleading in that for me the test steps/test sequence/test plan is only one part of it we have the invest and all process associated with that. For me the Process Integrator leads this whole process and reports stages to the E/E Integrator.

So I am not sure how this block here links into this process here? (Tailoring/post handover block)

That was just portraying in terms of the Tailoring effect, basically we came up with this RPD and he had a RPD earlier and he mentioned to put it in so that a stakeholder can see the process of tailoring. But I am concerned with this process here.

I was a bit confused in regards to the SOP? This process here 927, is this SOP? Or has this already happened?

This is the handover process, use a system called HM. So that is the handover process meaning that then having built the pre-series vehicle and the target is before SOP then process planning hands over the process and the facilities to the target production plant and the HM process and system supports that, allowing all the relevant parties to enter Yes Accepted or No and reasons why?

So this is Pre-SOP?

Yes, target is pre-SOP.

923-924 I do not quite understand them. What is your understanding of them?

So that is basically saying from the prototype build in Plant 0 with the reference structure we have the Intriebnameplan which in English is Test Plan and you take that into the target plant or plants then you need to tailor that reference structure to match the demands of the local plants because the structure is different or the specific demands and that’s what 923 is.

Then to validate if that is working okay. To build cars and to check if its ok.

Is this still prototype level?

Yes these are pre-series. At the end of the prototype build, the target is at the designing FITZ there are no more engineering changes. Then the product gets transferred to the assembly plant. Theoretically, the target is that there are no more product changes once they are in the target plant. But you still build these cars that are not for the customer but validate the design and validate the processes/facilities in that plant.

So the second is if it works well within the plant and if there are changes to be made on a Plant level. Is this right?

Yes, first step is to tailor the plant, describe the tailoring to the plant. Second step is to build cars and to validate that process.

Can you explain the difference between LU, L3 and L7?

So their product lines has been a shift within BMW now, they used to have product line L and a number, and the number would denote what the product was so 3 being the Mini. L7 is the 1,3,5,7 series. When we got a new generation of the 7 Series we gave it a brand new number and this we recognize was not given its best carry over concept from project teams. So now they have a platform.

LU is for all entry level cars. So for Mini and the 1 series. LK is then some of the larger 1 series and 3 series. LG is 5/6/7 series and Rolls Royce. What they are sharing is the same platform, the engineering platform, same base, chassis and same kind of engines.

Here in 912, gather and collect relevant information about the project, this is concerning the Process Integrator mainly and then we have 913. Could you highlight the differences between these two?

The first one is basically gathering the project information so basically the product description then down to the point where we need to look at what we believe of customer percentages or volume of particular option that would be ordered. This would potentially influence the process design if it would be on every product or might be slightly different if it were on only 5% of the products. So its that level of detail through to the detailed level of engineering and that we have a described project called TEQ “ishbrek”. The T for production organization, the E for development organization and Q is for the Quality organization, those three parties are on an individual issue sit together and go through what are the requirements from engineering and how does it work, what are the requirements from production and what could be the issues, again from the quality point of view ensuring design quality and production quality. Those defined meetings give all the info theoretically that we need to design the process. To write specifications for facilities and tools that will support the process that we want to run. So that the gathering information leads into the second step which is designing the intreiebnameplan which isn’t the test plan but its the commissioning or the start up plan.

The steps depicted in the process sheet, do you think its portrayed in reality? Or would you change anything in general?

No I think actually, it does describe the main steps but the responsibility for the process integrator.

Do you think that there can be improvements in the communication of these process sheets in the organization?

Definitely!

What would be your recommendations?

Find another format, because the processes are very difficult to read. Its just basically a difficult process to understand. Its well described, you know who the predecessors and successors are, however as a training aid.

But as a FACHT Team Leader, do you have any other responsibilities in this process sheet?

No the FT only have responsible for the function and process specialist level. FT runs the Process Integration process, this is basically their process and they run this process.

Thank you for your time.

If there were more questions it would be great if we could set up another meeting.

Yup sure.

It would be great if you could fill this out for me.

Peter D. Stanner

Role: Methodiker

Person: MT-P1

Date: 24/7/2012 14:25

Can you summarize your job duties here?

Basically, its the EE Methodiker which is looking after from the launch or when we have points of change the introduction of the vehicle from the electronic perspectives, there is usually two roles one is module B which is the harness role then there is the role that is looking at the changes to software, coding, packages and how that fits in regarding the different Isteps. So from what we get is generally we start a build phase at BVG which is what we are doing presently in Germany and then it comes here and we do PVL.

What are BBGs?

They are early package of vehicles that are not really production intent. You could build them away from the lines.

Are they Prototypes?

Yes basically between the prototype and the first production vehicles we build. Sometimes we make the BBG event online but normally they are done away from the plant.

So basically to summarize your role here is your involved in the pre-build phase?

When we talk about the pre-build we always are pre-building up till SOP. That is why we build different levels of the vehicle because you haven't got the finished vehicle till the end. There fore, we do a number of build phases

BBG, PVL, PS1, PS2, OP (10 Cars), SV (Cust intent cars) produced a month before to make sure everything is perfect.

My role in that is when it comes into plant any problems that are found are highlighted and are put back into the feedback loop so they are looked at the problem landscape and making sure if it is understood to define whether it is an engineering issue or whether it is a production issue.

So when you have a big role to play when it comes to the maturity of the vehicle?

Yes my role is all about feeding the car into the assembly and making sure the problems we have seen at the beginning are gone and or if they haven't gone we have fixes in so they are cured in the future.

How long have you been performing these duties?

Roughly 10 years but we have had a change 2005 where we moved from the old method of building cars with EE upgrades to the new I Step system which came in 2005 which completely rationalized the system and expanded the departments. The area of discussion for the Methodiker grew and I am a part of the SIT System Integration Team for TI 53U and also all the engineering colleagues we all come together once a week to discuss about the vehicle and that info is fed back into our engineering colleagues within Central.

Is this SIT different to the FACHT Team?

Yes it probably feeds into the FACHT Team. It is basically local level it looks into introducing all the I-steps when they are necessary and all the logistics around that introduction. They are looking at the new things such as changes to software or changes to coding and they are looking at the dangers to the assembly of the vehicle and the overall volume of the factory. So it is different.

So as you have mentioned all these duties are they the same in SBWE and PEP?

No they would be similarities in terms of the SIT team sitting in both. There are differences obviously from when we have a new launch it is different from a change point where you only have a few changes. Launch everything changes. So it is a landscape of changes. Workload would be a lot larger. We would have a bigger team as supposed to a change we may only have 5 or 6 things changes at a time. It is not easier to handle but there are not so many inputs and outputs, I don't have so many people coming to me and asking me about their parts or the quality in the landscape.

I have made a RPD with the help of Peter. So we have here the AK selecting the Process Integrator and then the PI kicks off the project. Then we have the TEQ and then the team is selected. Do you know who selects the team? Is it the AK or the PI for PEP?

I am not sure.

Then we have the implementation time, and then we have the BUZ Factor. What is this?

I do not know.

Then once the schedule is finalized we have the INPA scripts which are changed or finalized. Also then we have the PUs and the PLs being created. Do you agree with it so far or do you feel there should be changes?

My area more would be at this end, here is like I am a feedback function to the T-E/E Integration there. I am looking at these areas that are put back into the vehicle, and then examining the DBs from the CASCADE System to understand what failures are on the car and then to go back and understand why those failures were on the car and then to feed that information back in. The failures would happen due to the PL not being configured correctly or the parameters not correctly configured. So it includes in that area mistakes in coding indexes, sometimes the data is checked and it asks for a ECU with a certain coding index and it sees a different ECU with a different coding index and therefore it won't then code that ECU. Quite often, when we get new cars in we get issues surrounding things like that. The other issue is on the assembly side, associates ability to build the car. Missing connections or parts not fitted and this creates a lot of failures on the car and then we need to distinguish at the end what were assembly related what were engineering related and what ones are TI related (PL or Coding Index issue). That is basically my role. At the end of the day we have a Wash Up. Which is basically a meeting where we go through with representatives from TI, Engineering, Assembly and Launch. Another issue is due to the releases, which sometimes the wrong part is released with the vehicle. So that means that the wrong parts get on the assembly system and that creates issues.

Portraying your role here, you should be here with the testing and validating the PUs? Would that be right to say?

Yes it is test and validation of the complete build from the body coming into the assembly to all the rework.

So you are not only EE your overall throughout the plant?

No only EE but there are so many things surrounding EE. There are so many component, you follow the vehicle through to the F1 point, then you need to know from F1 to F2. If there are problems you need to know what needs to fixed on the car and it might be something silly like they fitted the wrong bumpers because it will be a knock on effect for EE as you may not be able to connect a part. So therefore you get a failure, and it is an electrical issue.

Do you interact with the T-E/E integrator at all?

This integrator here that would be me. There are two T-E/E integrators on plant, one looks after the Module B/E and the other one looks at the other modules. But on top of this you have also got TO-53 function, which is Electrical engineering function and they have got analysis of systems within their function. I feedback some of my info back to them.

Do you interact with the Process Integrator during projects?

I don't tell anybody what parts that go into the vehicle. I am downstream part such as informing them they have got wrong parts in the vehicle and I am feeding back to them.

So do you have both roles of a Methodiker and an EE Integrator or have I misunderstood or are they the same?

Well I am part of Integration, integrating the car into the plant. So it is both roles. Whatever it takes to make sure the car is right. Feeding back into the plant of what is wrong or what is right with the vehicle. Most of the info is coming upstream from me as there are integrators in Munich.

We have a third party which is MSF it's a supplier they do a lot of our tests. I am not fully conversant with our latest model but from 2005-2012 they took away a heap of engineering work which was central which they look after. A Lab car is a car with all the parts of the car on it for testing so making sure continual testing so they do that and they also do the software changes for ECUs. They are one of our partners. They are involved upstream. On top of that they have their on MINI now.

Do you agree with this RPD or do you think there should be changes?

There is a T-E/E Integrator there that is handing over to the plant when you doing serious work like just SBWE changes, you handover when you have SOP. Like we just did the handover for july for changes. Before there was a Central one and the Plant role but now it is combined.

I am still a bit confused with your job role, does it create communication concerns in terms of your role in the plant?

The communication network I have got in the plant is to build the car, we then gather all the data together. Then I lead a meeting where I bring in relevant people from plants and give them the issues that we have got and find out the ownership of the problems. Then that gets fed back into the quality system. If that is an Engineering issue it is sorted then.

Can that raise gAMS?

Yes it can at times. But you have got things like PLs incorrect , then TI53U they will look at that within a day or two. You have also got parts not fitted correctly, or process problems. I am feeding that information back into the loop.

Have you seen the process sheets by any chance?

I have seen some but not these ones.

Would you be involved here in an implementation role for agreeing necessities for EE document?

Yes, if a part does not have a testing PL then I would be discussing it with TI53 to make sure we have got a change as we have quite a few changes recently. There was a change we had to put in esp for rear window wiper.

What is PUMA?

I am aware of the name but not aware of the information.

How did you realise your responsibility when you first came?

Initially training. When you get to a certain level training, you know what meeting your supposed to attend and what problems/resolutions landscape software you need to use and where you need to raise your issues to. All this information here, all of if I would do but I haven't actually sat down with that carefully.

Do you think you can distinguish between 923 and 924 in terms of what is happening?

Well the first is going over your commissioning data and testing and sequences and your second one is confirming the working practices in the plant. Do you know your Cascade, ZMDs.

The first one is to make sure you understand the systems and the second one is it is working correctly in the plant.

Would you be involved here?

Only with the ZMDs where the parts are fitted that means if the parts are fitted in the wrong place they will not be tested properly. So those parts and processes have to be in the right sequence or at the right time.

Cascade test stands tests the vehicle. It is the A test where the ECUs are connected. I keep a check at all those stations to understand failure and where it is. Is that process working correctly in the plant is the second one.

Do you think that 927 is start of production?

This would be the start of BBG or development or PVL. So it’s a development phase, so we test all our cascade systems to get the results we are expecting. So then I give feedback about the issues.

So do you think that these process sheets are easy to understand?

If I had an hour or two I would be able to give you a fuller feedback. I am trying to just look at this now and tell you about it.

I can send you some flowcharts of how I see my role.

Role: Plant Process Integrator L3

Interview:1-3

Person: PI-P1-1

Date: 24/7/2012

The roles are very flexible. 5 mins ago I was the Project Functional specialist and 3 weeks ago I was the PI, FACHT Team and PSP.

The T-EE Integrator is through out.

It can be either Project/Plant PS or FS.

AOL is a PM tool to record the status of the Project.

MIP no clue.

Role: Plant Process Integrator L3

Interview:2-3

Person: PI-P1-2

Date: 24/7/2012

Can you please summarize your job duties?

In summary, as a Process Integrator I receive information, represent the group in the project reviews, analyse that information looking for that impact of that information on our processes which is summed up in to a test plan. Then discuss this analysis I have done or this information with the responsible people in the department and then I conclude the tasks that are necessary at the end we must come up with tasks or how much. Based on the information we got, some have an action to follow and some don't have an action. Some action includes making changes to the test plan which might be a new test plan or modification to an existing test plan or none at all.

Are there any other roles that you do at the plant other than a Process Integrator?

No

How long have you been performing these duties?

2 years.

So how are you involved in PEP or SB/WE?

I look after SB/WE because I am the Plant Process Integrator. So the plant PI is responsible for SBWE

What are exactly your responsibilities when it comes to SB/WE?

The planning of all EE aspects of SBWE falls on to me.

So it would be right to say that when there is an improvement or a facelift to the current series your in charge of making sure the current test plan is up to date to address the current or the upcoming EE changes in the vehicle.

Yes it is.

Have you ever had a look at the Process sheets?

Yes.

So in terms of the first process AK selecting the PI, would be similar for both PEP and SBWE?

Not quite. For PEP it falls at the beginning of PEP which is before SOP, because it is a new product so you don't have an integrator because it is new. For SBWE you already have an Integrator, so it is not a selection at this point of time it is this is coming, so for SBWE the integrator already exists because it goes straight to the Plant PI always for PEP you need to create a PI, a new product you need to give the somebody the task.

So when the information comes to you where does it come to you from?

Three main sources of information. 1) The fastest usually is Project Supplement. With PEP you don't have project supplement, its the beginning of the project we are going to do the car with4wd or 4 doors instead of 2 or whatever it's a new car. When it comes to SBWE, its at the end of the PEP process, you take the current model for ex, we did its PEP we did it years ago we have been building this car since 2006 and from 2006 SOP, changes that come coems under to the Project Supplement. So on top of this project we are doing this change or that change, so this is still the same project as PEP but when from when you start building it, it becomes SBWE. Any change goes to SBWE.

So would all of these be depicted in the synchroplan?

No

So the synchroplan is different to the project supplement?

Yes so the supplement is an order to the project to do something

So where does the order come from?

Project Team Ill give you an example so we have a project group called SK. So our current model is defined as L3. We have L2, L1, LK, LG so the one we are building now is L3. So what we have the L3 SK. They are the steering project team for L3 and this approves all the request from all sources. So the SK releases the project supplements. And how do these come about? So when we get the order from Project Supplement, there will be something behind it, it can be an improvement from engineering so in development someone decides that because of this Im going to improve this function here or make it faster and raises GAMS.

Is that Change management?

Yes Engineering Change management.

The GAMs is a request by the engineer on sources of information that I am going to make this change and what do you think? So I receive a notification of GAMS and I look at it and I think nothing, nothing and I look at it and ahh, if your going to make this change this is my statement, some of them I make a statement because I make an assessment that we have an impact we need to influence what they are going to do if they are going to move the electronic equipment from A to B then somebody in process planning will have a statement to make, I won't. If you're going to change the connectors, make it two connectors instead of one or reduce the connectors to one, then Ill have a statement to make. If you're going to introduce something new that affects our test plan then I will raise the GAMS, then the GAMS goes into the project then its released it becomes the project supplement. So when the GAMS is approved, then make this, it could be the other way around it could be an order from the project because of a customer requirement something coming from either quality or marketing so marketing might say we can sell this. For example, we need to cater the car with our new IPhone connectors it will come in a project supplement, so you guys need to come up with a solution for this because marketing require this so engineering need to do this or it could be fault somewhere so quality need engineering needs to fix this, so it could be both ways.

So how are changes communicated during SB/WE it could be from marketing or quality but more from the planning process side of things?

I don't see them from marketing or from quality, I can look its there. It is important to look to see what is coming in the next 12 months before it starts coming you have an idea by looking at the quality centre, qc records all faults so I can filter them through, actually if they can see this fault so this is what they might do so you start thinking ahead. But a source of information comes from gAMS through an email which gives me the gAMS number so I can look at the details. Also in DMS document management system and it automatically sends me an email of a profile because I have selected in the profile of all the things I want to see and I can filter it so I can get certain emails otherwise I would get tons every day.

So it wouldn't be true to say the Process Specialist or a Function Specialist also report changes like for example when they are designing the test steps or the sequence and they say this needs to be changed or so? Does this happen?

Ah yes that is a different kind of thing, it is not a source of information to manage change but it is a piece of information to take back to the project, take back to the engineering or the SIT so we can discuss this and say we can see this in our processes and we would like to see this here for example where we have done this and we raise a gAMS, normally I receive gaMs. Seeing the pass 3 gAMS I raised them and then people in the network also receive the gAMS from me and then in the system and they react to it and respond to it and then it goes to ECM board and then they do it.

I've told you gAMS is the main sources and then on the side of that we have ECP engineering change pack, this is very later in the change process. ECP tells you that it is coming. So all these gams or supplements converts to an ECP, the ECP tells you that it is happening. The gAMS is to authorize the change, telling everybody it is coming and when it is time to change it happens through an ECP. So this is another source of change. So at the end of the gAMS, the guy who is doing the gAMs does the process, he is always doing the Project supplement but it is upto the chamge management group to bring it in using an ECP.

I have made this RPD with the help of Peter, I have one question here. During PEP who selects the project team?

I wouldn't answer that with confidence but its up to the AK. The AK is responsible for what we do. Each group is under an AK. The System Integration here is under the AK and they will decide how they will handle the project, how many are we going to need, sometimes we may need more than one integrator it is huge. We may have a huge PEP project, so they may need two normally one. It is possible to split the project.

Is the Quality Specialist part of the project team?

No

But for SBWE do you select the Project team?

I am the Project team (Laughs). For SBWE I will give you an example if you ran a shop you already have the people in their place ie. Counter, shelving. So it doesn't matter what new product you bring in you know that it will be picked/shelved. So you just have to be sure that are you strong enough to pick the next one. So you don't have to select a new guy to do it unless s/he is not strong enough to do it. But whatever comes will come to his desk so for SBWE its set. What we have we call it the Werks Project Team it is already set so the WPT is made project reps from all the departments in this factory, process, change management, purchasing, finance and myself from the EE department. We have guys who do the EE Analysis and then we have the guys who do the EE Test planning. So in SBWE we do not need to select the Project Team because it is already there. There are small projects that come one after the other, you don't have to set the project team. But at the plant level when they have a new project, which is bigger than the usual SBWE they do select a project leader for it and they work with existing members. For example the two new cars, you see out there, we needed a project leader because we had to work a little different as it was a little bit bigger than the usual SBWE something similar to PEP but not to that scale but PEP like work.

When SBWE change has to take place what is the starting place? How do you initiate that change? How is it different to PEP?

To say how it is different to PEP is the content and the time that is a clear difference. Normal SBWE process usually minimum is 8 months but you could have 3 months or 2 months SBWE. Classic one is 16 month. I.e paint changes to part changes, plastics here and there. It may affect a connector where EE comes in. Can we delete this option or change this function or remove it? That is what generates PEP.

So the Olympic update to the vehicles are a SBWE Project?

Yes and its 16 months

You were in charge of it?

Yes.

When you asked me about how do I go about initiating it? It is 16 months before SOP, 3 weeks ago we launched the one that we were working for 16 months. We name it according to the month and the year. 07/12 ie. One month ago we reread the contect 15 months before SOP I give the team the project launch, so I have a project plan, analysis document, risk filter which I present to the teams. These are the risks with this project these are the areas we need to be concerned about. So the teams carry out tasks from those risks. So I have to present to the plant what I am going to do over the next 15 months. It leads to 18 month before SOP. So over the next 7 months I try to do the Project presentation or the kick off. 8 months before the SOP we start building the vehicles with new changes we call those PVL. The first vehicles are built with these options. It is the drop dead day on the car. We cant complete everything as we do need to do validations over that period. So 16 month project, 4 weeks later we do the kick off and then 7 months we work and get ready to start building cars.

So the Process sheets are more for PEP than SBWE?

Yes, the SBWE is a next track with these process sheets. Because it goes into.

Like Applying relevant changes into the plant?

No we do that, but it is not always expected. Because in PEP plan for the life of the product like big massive changes on the plants would have been planned into PEP. So when you get to SBWE, all these changes that we are making are already planned in. Its prepared for the life of the vehicle.

If you could have a look at the RPD, I have selected the Process Integrator here, what is the TEQ Leitfaden? Is it a technical discussion?

Yes TEQ we have them in SBWE as well. It is a discussion with us EE Process Planning which is normally is the PI and the Specialist who is in our group and Specialist of Controlling. Normally, you are looking at the Controlling you are looking at function tyre pressure function. But normally an function is within an ECU. But sometimes we get an hybrid where one function is within one ECU and some is within another ECU for whatever reason. So you have the PI, you have the TEQ and you bring in the ECU specialist and other specialists also brings in purchasing, development and we sit around the table to discuss around the content.

This is for both PEP and SBWE?

Yes

Sometimes depending on the weight of the change you do not have to do that, the TEQ might just be an email. I have looked at and sent an email to the relevant people and we do not need to do the TEQ for this. Everything remains the same but it might just be a connector being changed.

So we have the req catalog and Proj Imple plan and then we have the BUZ Factor, do you know what the BUZ Factor is?

Is that supposed to be Financial? If I looked at it I would know.

What about INPA Scripts? Are you in charge of INPA Scripts of updating them during SBWE?

No in SBWE we do them as well same as PEP, so if you look at this it is based on something completely new . If you look at SBWE it pulls factors from here which are relevant to that change, sometimes you have the change like introduction of the coupe and the roadster. We introduced a unit that was not actually new, we took the existing unit and make mods to it to do a function in this car that is not in the other cars. Here it will need INPA scripts. Other times it will not need INPA scripts as it will not be needed. I do not know if you know what they are.

They are global scripts are different from Cascade side, they are a universal script generalizing them whereas Cascade is for a particular series.

No.

Do you want to clarify that?

The INPA script is a description file of protocols over EDIABAS, communicating to the vehicle. Now to use Cascade, INPA or Tool set is exactly the same the front end is different and the function is different. So the INPA script describes what our people use in the most user friendly way. They can interact with it, I think you mentioned Global what is important is you can use it and not break the vehicle. You can use a Technician who is not an Engineer to run INPA scripts, if your going to give somebody a toolset they should know what they are doing and not damage the vehicle. This is because we have opened up EDIABAS to the vehicle for you to do anything to the vehicle and anything that is possible. We cut it down to INPA scripts if we want it to read faults it reads faults. When I do it with Tool set, I cant say read faults it will read a particular fault. In Cascade, I can implement a test that will read all faults except this one or ignore this one, these kind of functions that you don't need in INPA scripts. So the difference between the three is the application. So at the other end in terms of what is happening it is the same job that is happening only with INPA script you are limiting what can be done with it and you are making it easier with the interface you are giving him. The engineer may not know what he wants. A technician goes to the vehicle you know that he will not break it.

The TEQ Leitfaden is communicated to the FACHT Team. Would that be right to say?

Yes

Then the FT consists of the Process Specialist and the Function Specialist who decide about the PU and the PL, is that right?

Yes

Then you have the TVGs that are assessed, so Cascade is decided here when they are setting the PUs and the PLs here. Is that right to say?

When you say Cascade is decided here, could you please be a little clearer?

What I am basically saying is whether it is PEP or SBWE, take PEP for example, in Cascade the test steps and the test sequence are created for the new vehicle and those are made within Cascade?

Yes Cascade is just an application.

Then after that we have the TVGs that are assessed. TVGs are the human interaction with the vehicle on each test stand. So for PEP it would be created and for SBWE it may be optimized to save money by reducing human interaction.

Not necessarily, that is true that for imagine for PEP you would think it's a new thing so you would create new ones but actually when you do PEP as well you are not starting a new factory, it is normally there but sometimes completely different as you are adding a new function or a new part such as doors. It may be modified to change the TVG such as sliding doors. It may say slide but the door TVG will still be there. So even in PEP you assess it when it comes. For the TVGs when you have a new car, 80% will be the exact same as they are now and 20% new. It will be 100% modified though. Tweaks here and there change the names or change the vehicle name.

So likewise the PUs and PLs are also there not created?

Yes. It depends on what it is. Now we have Cascade we may launch the next car with this or we may launch the car with a new system so then the PUs and the PLs are coming in which are completely new. This system is not going to be around forever, Cascade came in 2006. It was replaced by a system that was there before and it will be replaced as well and whatever comes will be replaced as well. It can be when a new vehicle is going to begin or in-between a new vehicle build.

But that is a software upgrade it is not really upgrading Pus or PLs what someone said and it has altered my understand is that you still have the PUs and PLs and you keep the 30% and you add 70% where as for SBWE you will have a big chunk of it and keep the 80%. Would that be right to say?

No because of the percentages you may add 90% new I don't really know. It can also be 100% new or 1% new. When you say PEP it is expected it may be 70% it may be the case but you don't know. It is not clear cut. I can give you examples of what we have done already that I can give you with confidence. It is exactly this we are doing this much. I can give you from the last vehicle with confidence. It depends on the content. Let me give you an example, all the radios are new and all the lights are new but whereas for the seats they are the same and they remain the same. So it depends.

Here you have for PEP the test steps are created and validated and for SBWE they are revised?

Not necessarily. For SBWE it does not normally mean revised or optimization. I will give you an example that for SBWE we added a new ECU for tyre pressure control. SBWE new component so thus new test steps/sequence so new functions. We had 10 new parts for SBWE so designing PUs and PLs. We had to go through TEQ and FMEA.

So you must have had the financial feasibility for it as well?

Oh yes it follows through that financial process just as you see PEP, so it follows the whole process. So you can see SBWE can be as big as that or as small as that.

What is the role of a T-E/E Integrator?

The Integrator is, let me see if I can describe his role. We look at the Project from EE Testing side of it. Unfortunately we keep saying testing but we don't only do testing. Testing is a small part of what we do. We look at integration of a vehicle into the assembly. We look at the integration of all EE stuff/ subjects into assembly to make sure we can build the car,that is our work. To make sure the car can be built and to deliver the product the way it is supposed to at the end of the process.

The Integrator as I understand, do not quote me on this as I am not very sure about the wording, he looks at the vehicle from the customer point of view as he has to deliver the function. You are developing tyre pressure monitor, I am looking how I am going to integrate into the plant he is going to look how it is going to work out there. How we are going to deliver it. Is it meeting all of the requirements? Does it meet whatever? Also the legal requirements I don't know.

So his role is prior implementing on the production floor?

Oh yes, way before that. He is the FACHT Holder for EE topics.

What does that mean the FACHT Holder for EE Topics?

Well he is responsible for EE components in the vehicle but we are responsible for integrating it into the plant. But he owns it.

So the AK would communicate with the E/E Integrator in terms of the parts that are going into the vehicle and the EE Integrator communicates with the Process Integrator early on here for example?

Our existence is symbiotic if that makes sense. That means we share, so we exist in the same plain. So we don't go to him for this, he doesn't come to us for this as in hierarchy, but we work in the same plain. We look at the same information with different eyes for different end purposes.

So basically the Process Integrator would be how am I going to integrate this vehicle into assembly but the E/E integrator would be how the parts integrate into the vehicle. How am I going to introduce this function into the vehicle. How is this coming together.

So where do you think the E/E Integrator would fit into this diagram?

No where. Only if I was to think about the communication line with him then, hes part of the TEQ, if that makes sense. He holds information rounds because he knows the product more than we do.

So when the PUs and the PLs are being configured then the EE Integrator would have a part to play?

Oh no that is in development, because in the end we produce the SGBDs. The EE Integrator is not interested in the tests.

He is just interested in how the parts fit into the vehicle.

We are not just talking electronics here, the vehicle is big.

So where would be the QS be in this? After the Handover? Would he be in SBWE?

I don't know where I would put him. Because I don't really work with them. If you want to see exactly where they are then you look at the Process Planner, they work with QS. In our case we have the Test Planner who is the Process Specialist. They work with the QS and the Project Leader. They work with them more than I do. The only time I come across QS when I come across a quality issue like how our process may arise a quality concern.

So the only difference between SBWE and PEP would be the Team as your team is already selected?

So that is not the only difference it is a difference. SBWE is daily business we already have a team so SBWE always comes to me. PEP the project doesn't exist so we don't have a team. So at start we need to select a Process Integrator makes sense.

But for SBWE once the gAMS has become a Project Supplement then it would come to you and you are responsible for it?

Well even before gAMS it is coming to me, we already had a discussion.

As you are the Process Integrator for SBWE do you feel that there are any communication gaps or concerns?

Yes concerns about our own processes. There is a problem with the maturity of our processes; this (SBWE) was not there long time ago. PEP has been there a long time. But there will be hysterical hindrances to a new process. I think it was 2 years ago we started doing the Plant Process Integrator role and it's a learning curve for everybody. As we are learning, its changing. You were looking at the Process Sheet that was written a while ago, the interpretation also not long ago also needing to be improved every time as we dealing with it, it changes. As the PI here I try to do things best way I feel guided obviously by the Process Sheet 9.1 and somebody else in another plant is trying to do the same of course there is the pressures of your own group trying to influence it in whatever direction and gaps would be there. I wouldn't pick on any specific gap but there will always be gaps and room for improvement.

So did you use these process sheets at first for projects or when you started training someone, were they communicated to you or were you trained?

The first thing I did were these process sheets, looking through them. Also we had a team event where we all went through them. 9.1 and 9.2 spent a day going through them.

How useful are these process sheets to you?

As a guidance they are very useful, but it is not a tool I use everyday.

So would you agree with the steps in the Process Sheets?

I wouldn't say I agree with how they are described entirely because it is ambiguous. Not all of it, some of it is very clear cut. But if you make it too specific then these process sheets may need 1000 pages because you will describe everything detailed. So I can understand why they are described generic as possible. Then it is subject to interpretation and it creates ambiguity.

But in terms of the sequence do you feel it is reality?

Oh yes.

So how are these process sheets communicated across the organization?

We have a clear pyramid we follow. We have a pyramid, we have a DMS and we don't keep copies of this. So whenever you open it you know it's the latest.

How do people in the organization know their responsibility?

They read the process sheet, it is very important.

Do you think there can be improvements in the communication in terms of these process sheets?

There is no way I could say there is no way to improve something that I would never say. I believe in constant and never ending improvement. I don't know if you know KISEN. It is a Japanese thing. (Mitsubishi) Now that is something I believe it. To your question now, I can't be in particular and say can we improve in how we communicate. I would say can we improve it in the way we approach it ourselves, if you see it as this domain thing that comes to you it is difficult. It is a personal thing. If you become proactive and start working with it, even against your own will it will come to you much easier. The way it is communicated with you is easy it is in one place, everyone can go there and you know your role. You approach it as this is your role. I don't know how it is communicated with new people and when I came into this role, that is the first thing I was shown and I was shown where to get it and shown through it.

How would you improve the communication to these process sheets?

The communication, I would say that it should be added to the Skills Matrix.

What is that?

The Skills Matrix portrays the skills in the group. So otherwise how people know their process or jobs as explained in the process sheets. At the reviews then we would know how well people know their jobs.

How would you improve the Process Sheet?

Well better interpretation in English.

What about a Graphical format?

Just wording. Some of the translations are hilarious. Its not about the fun, it's easy for me to look at them and try to understand what they actually mean and find out because I already do the job. If you don't do it, you will sometimes struggle with the translation.

Alright thank you so much. I would like to have another meeting with you another time.

Peter D. Stanner

Role: Plant Process Integrator L3

Perosn: PI-P1-3

Interview:3-3 (Skype)

Date: 03/8/2012

You're the Process Integrator for SB/WE, during the SB/WE you mentioned that one of the ways that changes would come is through the gAMs?

Yes that is correct, the most obvious or common way is through the gAMS.

You also said that for the SB/WE projects that you select the team or they are already defined?

SB/WE is ongoing business so it is defined from the beginning. We have so many projects at the same time and it's the same time every time.

This is because that I was creating the models and I thought that it was adequate to say that the AK defines the team for PEP but for SBWE it is moreover the Process Integrator?

SB/WE in effect it's the AK that defines it and decides who is going to be the PI, so for PEP right at the beginning who will be the PI they are going to decide that from the beginning. So at the beginning the AK will decide that all SB/WE projects to come will go to this PI at Plant Oxford.

So when they already know at this plant this person is going to be in charge of SB/WE projects so the team will already be defined?

In other words, we are going to have SB/WE projects anyways AK defines who is going to be the PI for the plant and when the projects come he will be running it.

And for PEP from your understanding how does it work?

For PEP its not plant its central and in the beginning there is no project that is the difference between PEP and SB/WE. The plant will already know about the SB/WE projects which are to come but for PEP it's the beginning its point 0. For example, this guy is going to be the PI for these projects .Does this make sense?

Kind of but I had a question. If the PI is chosen at Plant 0, would AK choose the rest of the team?

n.r.

What do you mean by rest of the team?

n.r.

The process specialist/Function specialist etc for the PEP project?

Most of these are already defined because if you have say the tyre pressure control system, you will have systems specialist already and say you get a new PEP project and the AK appoints a new PI for it but for the tyre pressure topics you already have a specialist. Sometimes you have a new module which is very common, something that we don't have already then we may need to appoint someone who may be a specialist in that area but it is not always the case that you will select a PS, FS, System specialist, motor specialist no, these ones are already available. Say if you had your company you already had your Financial Controller, it will be the same guy for all the projects and you already have your managers. But say if you deal with plastics but you don't have an idea about plastics so you appoint someone there. Same thing. But always, in any company for a new project you appoint a project manager because that project doesn't exist already. It's the same thing as selecting for PEP process integrator the others are already there.

If you could explain to once the paper work has come and you have signed off on it that yes we do need to do these changes then what happens?

n.r.

Mean for SB/WE?

Yes.

I get a notification from whatever sources I have gone through, it may be a phonecall that we are planning on doing this. Someone is telling me of doing this because they are working in a network. An engineer calls me from development and tells me that because of this issue we are planning on doing this. He is just telling me about it he hasn't raised a gAMS. He is planning on changing something or implementing something. My task is to analyse the impact of that on our test plans. It could be me reading it for 5 mins and saying zero. I could be working for it on an hour. It could be simply telling the guy next to me he may be the specialist and may say no that's nothing and we finish it there or he may say give me 10 cars to try this. That one actually means that we have to do some tests over a 1000 cycles. It could be anything. What gets the ball rolling is to analyse the impact. Do I close it here and there or do I discuss it with the Specialist? Or do I take it back to a wider group the FACHT team to get more knowledge from them. I think I mentioned to them before that we had a system before and we took it back to the FT and we have this system and has anyone dealt with this before? That is in SB/WE but its linked with a new product.

But again there would be a project start letter that would start the SB/WE project? Would there be any other document?

You mentioned I talked about the Project Supplement. So a project in SB/WE is a part of PEP. You remember when you start with PEP 6 years out and you launch the product that is the end of PEP but the project remains such as Project R56, it will always be

Project R56 and anything that comes after is a part of that project. So you don't need a letter to start the project, which started a long time ago. This is now called Project Supplement because Project R56 they add something or remove something. Its not like PEP.

Gather and collect relevant information for Project which has EE ProzessBaukasten, LeLe, PUMA, KMG. Can you please tell me a little about PUMA?

It is just a database, we actually call it the PUMA master list it is an Excel sheet. It has all information for all projects. But for your project, you get your extract rather than getting the whole database. If you have it in SAP and going through the data is hell, what PUMA does for us is getting an extract just what you need. Also, the stuff for only EE and then that Excel sheet is something we refer to check that we have synched the new project with project supplements, gAMS whatever then we go to the PUMA sheet and synchronize it and that what it is.

KMG is also a database is it?

I think it is, but I don't use it.

913 I am a bit confused with commissioning the word now? Do you know what it is?

It is not commissioning of the project it is commissioning of the vehicle. So what happens is if you are going to integrate any EE into the vehicle you will have to initialize the ECUs and how to program them or code them and to test them and all of this does not happen to all units in the same way. So that is why you need to prepare this. Some of them need programming, most of them need coding, most of them self diagnostics and test peripherals some of them don't need this or have their own ways of testing.

So basically integrating the EE parts into the vehicle is that right?

Yes

So if they need any adjustments or modifications that is whats happening here?

Yes.

So it says here that for Binding Documents there is TEQ Leitfaden and for SB/WE it says depending on project so is that if for SB/WE if there is a project supplement you are just going to add on to the Project Supplement?

It depends on complexity. For PEP most of the components will be new so will be the vehicle so its added complexity yes?

Right

For existing systems or existing vehicles, SB/WE is modifications to existing specifications something that is already there so if there is a small software change that will not be noticed then wouldn't need a TEQ. Sometimes we may change the timing that is all in the project supplement or gAMS. Sometimes depending ont eh complexity or rear spoiler problem we had to use the TEQ although it was in SB/WE and it was in the project supplement we had to do FMA (Failure Mods effect and analysis) depending on the complexity depending of the content of the project we would do the TEQ for it.

Do you deal with this E/E ProzessBaukasten?

Yes

Can you tell me a little about it?

Well, the PB defines the processes this is derived from the Process Planning Partner because that is normally what they fitting things, do push pull connecting things. Within EE we get a little bit of ProzessBaukasten where our Process Planner has to plan where they are going to do work in the EE testing/ commissioning. It is an extract of the big PB from our partners for the EE part redefined into the EE ProzessBaukasten.

So is ProzessBaukasten Process blocks?

Yes, it defines those processes

So your going to have a really long process block for the EE side in the ProzessBaukasten for the vehicle build defining how things are going to happen for the EE so basically it is going about how you need to do the EE components in the vehicle?

So that is main of the main Baukasten, this is defining for our Process integration in testing coding programming and initialization.

Is this an input document?

It is a document that defining how things should be done. It doesn't go very much into the detail its high level. Its defined by the development. Everybody who develops it has to define it. Whoever develops it amends it. For PEP we develop process for commissioning or initialization in this we need to define the Baukasten. It's a MUST. You need to look at the Baukasten if it still applies if it doesn't then you need to make sure it applies.

Would you have a Baukasten? A Generic? If Peter would have it maybe he could show me?

You can look online I am sure you would find one. I have read through a few but Peter would be able to get it from you.

913, it says the Management role is PI and for the Implementor is the FS, PS, Methodiker, QS. As a PI, would you just be supervising these people or would you be participating to a certain extent as well?

Supervising is not the right word and remember it has so many grey areas because we work together. Our backgrounds are normally in process integration being a PS or Systems Specialist. Remember I was a Test Planner for sometime and I worked with the Methodiker and QS, the PL all these guys and I bring something as a PI I work with them. For example, if I have something that Peter has to implement something but the responsible is mine. I am going to report the task to my superior when it is done or reasons why it is not done. So I keep responsibility at the same time AK has accountability for it. Everyone of us is responsible for their individual task. So for this task to answer your question the soul responsibility of our work is the Process planner he is responsible for the implementation. I am still responsible on the work to be done. In my plant I showed you my Project Plan and reports. In that I have entries and these are the entries and these are the outputs and one of the outputs is to be implemented. That has to be implemented. We have doen all this talking and Peter has to implement it for example and they have their deadlines If it is not then for whatever reason it is not. Or it is not done at the time.

What is this Intriebnameplan? Is that just a test plan?

Yes

At this phase here, necessities document for EE Testing and your are clarifying who is responsible for what in terms of the tasks, the components or the changes you are bringing and updating the TEQ and you look at the ProzessBaukasten to update it, is that what is happening here?

914 This is the analysing phase. You are asking what does this info mean, does it mean that we are going to make changes to that model. Then the guy who is responsible makes a TEQ for this and agree when is it going to be done. Also looking at the TEQ, it will need that and that and that and when is that going to be done and who is going to do it. If you go further, then you ask yourself how it is going to be done. Also if you go further, it will go to the Technical requirements the system requirements in terms of the test systems. The infrastructure which we may need to modify or amend.

Set up adapt testing knowledge and make it plausible for plants? Here it is FS for all three roles. But its just the Test steps that are being defined?

Yes so from the discussion what is going to be done the PS together with the FS work on where it is going to be done. The FS is going to define the step and this is the way it is going to be carried out it maybe the same person the PS depending on the requirement it may be the current measurement. Peter for example looks at the FRM and he defines the FRM thus he is both the FS and the PS.

So say for example there is a new product they need to bring in new test steps or alter the test steps? Who would be doing that? Or does it depend on what it is?

Well it depends on the content. Let me give you an example, if we are going to measure something for example, the current module. That one there we shall do current measurement and Peter owns the process for current measurement so we will define the steps and owner is Mike Holks. So he is responsible for defining the steps but Peter is responsible for implementing it so they will work together. If it is one person defining the steps and implementing it then that’s that. I can give you a simple example, you have your factory and the finance guy is responsible for introducing that financial change, he is responsible for running everything in there. So that change is actually an IT change so he will have to bring in an IT guy. Actually, its something in the software that is changing he doesn’t know much about it so he is getting the IT guy to do it. But however, if it is a finance change then the finance guy doesn’t need the IT guy and will do it on his own.

Make sense?

Yes

917 and 918 it creates confusion if you clarify it please when it comes to SB/WE?

In PEP it is very straightforward, you make the steps first then you make the sequence. In SB/WE it is exactly the same but maybe not to that depth. In SB/WE most of it is already there when you have something new then you do test steps it may be new or modifying or adjusting and next part of the sequences where does it fit in, it is exactly same as PEP or take out whats not needed or relocate to a new sequence.

Would it be right to say that in the Process Sheets for PEP it is straightforward but for SBWE there are some processes that might be optional. Would it be right to say that?

No they always happen. When you are doing the test sequences, you are assessing them that they need to be done. All these processes happen. 918 can take 1 minute for you because there is not much changing the sequences. There I would be assessing the sequence if there would be a change in them. But all of these processes happen.

921 commissioning..so is this checking if the facilities and the equipment at the plant is ready?

Becareful, with the word commissioning doesn't necessarily mean commissioning. This translation is not the best so that doesn't mean commission. When you think commissioning it is not of the project. In other words how are we going to integrate these new features into the vehicle. How are we going to do it. The coding, the initialization of ECU systems. Here what they are talking about it is in PEP in 921.

920 is integrate course of commissioning into equipment?

So 920 is you look at the test steps and the test sequences which are going to run and how many we need and all the what equipment do we need and all the peripherals with it.

Role: Process Integrator Plant 0 - LU

Interview:1-2

Person: PI-P02-1

Date:

Can you summarize you job duties?

E Process Integrator

Transferring Data from the Project into the Team

Time Frame

PI will have separate timetables for all aspects (Equipment etc)

Have long have you been performing these duties?

7 years (4 years in SBWE and 3 years now in PEP)

How are you involved in the PEP or SB/WE planning process?

Similar steps for both.

What are your responsibilities?

Gathering data for the project, with timeframe and costs and justifying those costs esp for PEP. Having a steering committee and team and the FACT Team is contacted to set up all of this.

Whereas for SBWE is more for I-Step and it is more plant level.

How is this process different to the vehicle build for the SBWE planning process?

Work is similar but for PEP there is an exact date and the financial aspect is critical and needs to be justified deeply. This is at Plant 0.

But for SBWE, there are I-Steps and it is on a Plant Level.

Are SBWE changes communicated with you?

There are regular monthly meetings with the FACT Team and it can be discussed there. For ex, person responsible for A Test will communicate and synchronize this across all plants.

Are there communication issues here in general?

There but more on a personal level, some employees like to communicate whereas some don't. (Due to time consuming)

Are you completely aware about the Process Sheets (9_1)?

Yes I am

How useful are these Process Sheets? (Why is that?)

They are useful when there is an employee new to this role. But the reality different it is briefly the surface of the project i.e.TEQ Leitfaden

Across the organization how is this process sheet communicated? How do people involved in this process know their responsibility?

No they are not but if there is someone new I would show them the process sheet. But also from their job desc they would get to know.

Can you explain the BUZ Factor?

NO

910

Bestatigung Zelrahmen – Confirmation Target Synchroplan is a plan for 60 months which portrays the milestones and when the product is going to be launched.

911

Bestaigung Markeinfuhrung and Prozess – Milestones and Process Secure (Are the milestones on target). Is the vehicle plan on time.

AK EE Process Planning – group leaders for each dept.

FPL der TMO – Technical Leader (Assembly) (To ensure that plants are ready in terms of equipment facilities to be able to setup or test the vehicle)

912

PEP:KMG (List of every nut bolt and part which will go into the vehicle) (Project teams decide this)

SBWE : PUMA (Update list of parts/changes to the vehicle) - should be renamed according to his explanation

913

Is a detailed description about who is responsible? What we have to do ? Desc of each component. (Calibs testings, more relevant info (Documented))

SBWE normally updates the current TEQ Leitfaden.

ProzessBaukasten

Collection of Best Practices. (How to est a process) What is the best way.

Do you see this process model as useful?

Peter D. Stanner

I agree with the Process Sheets and it is very useful and easy to follow

Role: Process Integrator Plant 0 - LU

Interview:2-2

Person: PI-P02-2

Date: 27/7/12

Just to summarize you are the PI LU?

Yes that is correct.

There are two Process Integrators one is sitting in FITZ and I will take over the Plant Process Integrator.

So are you shifting roles?

PI for the PEP phase in Central is a bit different to the PI in the plant. But more or less it's the same role.

My understanding of PEP is more planning and whereas on a plant level it would be more hands on approach, taking those plans and maybe implementing it.

So may be to update from that day, I have updated the RPD from the other day.

Can we have more than one PI, can it be Plant and Project or just one?

In Central, there will be a central PI and whereas for the plant it will affect three plants Oxford, Leipzip and Reginsberg so you need people responsible at the three plants.

Would your responsibilities change if you were L3 or LU?

So normally it should not change.

Is it right according to you that the AK selects the team or the PI?

Well its both of them. If I know I need people from several depts. Then I can check with the group leader to use them. But then the AK can also do it.

Could you tell me a little about the TEQ Leitfaden?

Its an EXCEL file which gives you an overview contents of the TEQ more or less the interview with our dept, development and the dealership. At first we ask stupid question if there is an SGBD index so it is a specification. It is generic info that we need to do. What is really necessary so that we can build a car. Is it necessary to have it? How can we make sure that each connector is done correctly?

From all the questions when you get answers, would that then be the requirements catalog?

Yes, it is. We get the requirement of what we have to do during our project implement test, this way it is correct. Req catalog can also be the beginning of the project. This is how much we can offer you but then you have to pay 1 euro per component then a discussion is followed. But however after the TEQ discussion, it is an opportunity for us, it passes us all the information we need, if a component can not do what it needs to do then we can escalate it as a function.

I am having trouble understanding requirements. A req is if I want to have a car which is 5 gears with automatic is this a requirement?

Yes, sort of and then with these options or these extras.

From the TEQ leitfaden it is not exact we neeed these parts, its more of a discussion?

No it is not only a discussion, we have a few reqs which are fixed in specifications and the TEQ leitfaden is another possibility to make sure that all our req are okay or fulfilled by the supplier. Sometimes we see misunderstandings which need to be clarified.

According to you, after the Teq leitfaden has been done, what happens next in the PEP phase?

We have the TEQ Leitfaden is more parallel, we start to generate Test Plan the Inbetriebeplan.

You are not involved the BUZ factor?

It is basically in PEP phase, if you have this much money how they will spend this money. There is a German word that I saw that describes this maybe it will help you understand.

These are targets where we have to report how much money do we need and how much do we get and also how much time do we get. I can show you a file where we have two targets. One target is the TIME, so as you know you don't need much time to build the car because that determines the cost. There is another target called TVG time. TVG time is everything in detail written what sort of test it has to do and how long does it take, so its analyzed by the dept. The last target is money. MIP is MultiInvestmentPlanner. It is basically how much money do you need. Each stand has a PPG structure, so lets say Diag it is a number so then I write in to the FT it is the PI FACHT Team and then I define how many stations do I need. So 40x10 stations =400,000euros. Also when do I need the money and when I raise an order, I need to make sure that the money is available.

Quick question do you have the Quality Specialist or the Quality Integrator in the project team?

No.

So it's the Internet application MontageInvestPlanner then you can make different folders such as Oxford folder. It will say here if there is any money available for Oxford.

For developing the PUs and the PLs is it more Plant or Project Process Specialist?

Peter D. Stanner

It would be both.

What about SBWE just Plant Process Specialist?

Yes. It will definitely be more Plant PS. However they are now working together they are weekly or monthly meeting to the FT. Peter will meet with his colleagues every 4 weeks to have a discussion.

About the BUZ Factor, the information would go to the EE Integrator and the FACHT Project Leader?

Yes and also we will also inform the AK.

RdE StandardSoftware, do you know anything about it?

No what is this? I don't know this.

FITZ is where all the planning happens and Plant 0 is where you build the prototype?

They are both in the FITZ it is just a different dept.

927 - What is your idea of SOP in terms of these process sheets?

No its output delivery.

HN what is that?

HN is the document or the official agreement few points maybe yellow between the planning and the plant. Commitment of the plant is able to produce the car. The document goes to departments where they are now responsible now.

So in terms of the Process Sheets, is this a confirmation target on the synchroplan and whereas this about validating the vehicle to the market and the validating the process?

Yes although it's a synchroplan and this means more or less the same but only for the car and yes the car is well done and the project too then the dealerships starts by ordering the car and its about communicating with the dealerships that this new car is available and it will be entering the market.

That is the market part what about the other part?

Yes it is the same process, this is making us able that our processes are so good that it allows us to produce it in a series.

Does it have anything to do with time?

No nothing to do with time. So for example, after the plant shut down we plan a new process for assembly. This is necessary that it works. So you need to confirm that you are able to build 1000 vehicles or so per day.

What do you think is happening here 913 agree and document on necessities on EE Commission?

This is more or less our point not on the synchroplan that at a certain time we want to have all the necessary information such as all the docs suchas TEQ Leitfaden. For SBWE, for example if there is a new radio then the info regarding that and the output is the testplan and everything is prepared for that model.

So would you have a TEQ Leitfaden for SBWE?

No you don't have it. Normally because it should be this way, if we launch a new model like I showed you from any component in the TEQ Leitfaden, so maybe they change it a little bit so it is not reqd to make a completely new TEQ Leitfaden so you just add to it however if it was a new component such as the main unit 2 years later then you are responsible for the TEQ Leitfaden although it is not a new vehicle it is a new component project.

Basically to summarize what your saying, if there is a new component coming 2 years down the line then that would bring in a new TEQ but if it was just a change to the current series then it would updating the current TEQ.

What does this mean Influences on current Product?

It is on a very early time the outputs is the requirements catalog that was why I asked you a few minutes ago what do you understand under this. This is very early stage in PEP maybe 5 years before the model goes into production we have a req catalog more or less a wish list what we want to have in the new vehicle. If you write down you want something automatically you will never get it. It should make sense and you look at the existing project what is ok and what went wrong and you try to make a new requirement if you want to initialize a window it may not work and you find a better way to do it. In LK we can switch on the ignition of the LK of the car in the diagnostic and it was not possible with L2 or L3 and we may have the possibility to do this automatically as this may save money for half a minute per station.

So it may be from marketing that they may require this and it may be taking care of this.

But we are not taking care of marketing we are only looking after assembly.

What needs to be done in Engineering for example.

Setup initial commissioning and make it plausible for plants. Is that moreover the scheduling side of it?

Yes

I think it's the English name Commissioning schedule Inbetriebnameplan this is what I tried to explain before for example if I take the airbag component the commissioning plan the Airbag has to be coded in A Test and activated on B Test and connections will be tested at F1 diag as an example and set this implementation plan. So at the end of the day you will get a list in any form as we are shifting so it is not easy and you can filter airbag and can see what happens to airbag at what station or according to test. So this is inbetriebnameplan.

When they say set up initial commissioning or commissioning schedule what does commissioning really mean?

German is called Inbetriebnameplan so it is the first step to get the car running at the end of assembly plan. Really write down the plan so for A test w eare doing this this and this and for B test we are doing this. During this plan we see that it does not work as you would want it to work. As some of our colleagues have moved a part so the commissioning plan then changes.

Setup adapt testing knowledge and make it plausible for plants and that is again your test steps or is that your test sequence or PLs or PUs?

This is your PUs. Do you know a little about Cascade?

Yes I do.

So this is more the Test steps so it should be the function specialists but it is the Process Specialist is implementing but here its more Test sequence and it is the process specialist again.

Process Specialist is Test sequences and test steps is more Function specialists however they should work close together and sometimes they are the same person. The only difference is what is written here this one is prueflink which is the test content of any component.

So lets take Airbag for example, Prueflink is always I say is a container and you take a look inside and you pull out what is inside but only one component. Everything what you can do with an airbag is written in the prueflink and also to read the read. On the other hand Pruefemfang the Test sequence belongs to the test station so lets say for example A Diag here are all the test steps that are running on the test stand. But you can imagine this station has multiple tests running not only airbag but other components as well this uses than one Prueflink.

Who is in charge of setting up the TVGs?

At the beginning it is the Process Integrator but he can delegate it. It makes more sense that the specialist set it up.

At the end of the day, it’s the PLs and the PUs that determine how the TVGs are set up and they are directly affected by them?

Yes, that’s true. For example, TVGs are based that where we need an associate, we have a lot of tests where we don’t need an associate. So therefore we may not need a TVG.

Integrate into all plants, prior this your working with one plant, but if Oxford is only doing development then how does make sense? Do Leipzig and Reginsberg also produce MINIs?

Not yet but into all affected plants is the reason why I am here. Few years ago or today Plant MINI is more like an island because it is the only plant. Say in the future, half a year Oxford will produce then half a year later then Leipzig and half a year later the third plant but in the future we are planning on to building the MINIs.

So in the future the goal is to make all the plants flexible to be able to produce cars?

Yes. So but with E/E there will only be a few components that will be different and only the car that will look different and the engine and the electronic will be the same.

What is being approved in the FITZ here Conduct intermediate approval in the FITZ?

I think it’s the handover from plant FITZ to the Plant Oxford. Plant FITZ is building BBGs they will then handover the plans to Oxford to build PVL phase. So all the document and I will ask the coding components to be in a test plan. And then deciding who will take over the project.

Here it shows 922 is before and the next one is 925, it jumps I don't quite understand this? Should you see that if there are any problems then you go to this step then you go to the next one.

No I cant explain this one. If all is working then you don't need this but you will need to validate it. You are right I cant explain you this, it should be validation.

Even here it goes 921 then 923 then 925 because 924 will never happen.

It might be an error I think.

How are these two different?

If you are building the car in one plant you don't want to do the work twice if your adding a system here in Oxford and when I go back to Leipzig I don't want to do it differently there. Also if there is a problem at Plant Oxford then analysis should be done and the info should be sent out to all other plants. So we don't need to do it again at the other plant. If the error occurs in Plant Oxford and if they are not specialised they can ask another plant to help out. So two plants are working on the same problem.

This SIT do you interact with them? Is it right to say that they only support SBWE or they support both?

No the SIT Leader normally only supports SBWE because the leader is placed at the plant and has only plant projects. Although the SIT leader is responsible for new products however the series is already ins serious production.

Thank you so much.

Welcome I hope I can help.

Role: Plant Process Specialist

Person: PS-P1-1

Interview:1-1

Date: 29.08.12

Can you summarize you job duties?

Taking the input from Development. Is also a Process Integrator.

Creates and works on SGBD scripts

Creates and works on INPA Scripts

Are you involved or aware of the 914 and 911, 912, 913, 914?

912 – Is a supporter LeLe is Lessons Learned

914 – Delegating tasks

916 – Preparing equipment

917 – Filling Cascade

Are SBWE changes communicated with you?

Each plant has a SBWE change management. i.e. the new istep needs a new SGBD.

How are PEP changes communicated?

Through the Functional Specialist or Process Integrator at Plant 0.

Are there communication issues here in general?

Technical Data and multiple roles.

Are you completely aware about the Process Sheets (9_1)?

Never seen them.

Across the organization how is this process sheet communicated? How do people involved in this process know their responsibility?

Never seen the Process Sheets in FIZ. Most people dont

Can you explain the BUZ Factor?

No Idea

What are INPA scripts?

INPA scripts are Rework scripts which are universal tools to interact with the vehicle easier.

The Difference between a PS and FS?

They are the same for him.

What is FPL der TMO?

No idea

What is a Meister?

The Supervisor responsible for training

What is KMG and PUMA?

KMG no idea

PUMA – Master Process of Updates

Notes:

Bestatigung Market and Process Securing – Validating of Intro of Vehicle to the Market and Validation of the Process

Two types of TVGs – Paid and non paid.

920 – Vehicle test big process. (It is not clear.

921 – Validating and commissioning 920 at FIZ Level. Running 920

922- SOP already and tailoring at the plant.

924 and 925 ??

927 – Construction no clue might be assembly.

Role : Functional - Process Specialist (1 of 2)

Person: FPS-P1

Date:

Summarize your job duties?

Im here to initially to resp for rolling road ABS Mo Test to support the dept while a apprentice is brought up to speed then he will take up the ABS responisibility from myself.

I'll continue to be resp for Mo Test. But Im also sub project leader for LU projects F1 and F2.

For LU we have the new equipment going into the LU rolling road. This is to be done before the shut down.

How long have you been with BMW?

Returned to BMW beginning of last year. I was away for a year and I came back.

LU is the Standard features on the Vehicle?

LU is the standard platform on a vehicle

L2-L3 are different plants.

For the Business, LU is there to make the business more flexible.

Are you a Process Specialist? Are you a Functional Specialist?

Yes and Yes.

Are the roles ambiguous?

No

Peter D. Stanner

How are you involved in PEP/SBWE?

Im not.

Have you seen the Process Sheets?

No I have not

What do you think about the Rich Picture Diagram?

It seems to me that this is mostly Munich Based. I come into the Facht Team that is where my role is. E/E Is our friend M.Baum.

What is the BUZ Factor?

No Idea.

Do you know much about INPA Scripts?

No that will be Andy Bird.

TVGs?

Peter

What is your role on the Facht Team?

Looking at the Facilities. Looking at the TVG aspect but it is not that dependent. Because car will go through the cycle regardless. The car simply follows a sequence on the test. TVGs are a good time to recover time on the floor.

NOTE:

The PI does not normally choose the team. It is selected by the Line Managers. Or maybe it is selected from Munich.

You have all the diff teams at the plants, each one has a line manager on top, each one of those are in the Kries team (Should check that).

Lead Planner – Front end and Realisation Planner will make it happen.

LP may be in Munich or in the plant. Depends on the Project

Facht Team is made up of individuals from each plant.

How are changes communicated in SBWE?

No I don't get involved in that.

Line 923, would you be involved in this which is implemented in all plants?

Yes I would.

Why is only a PS here why is a FS not playing an implementation role?

It's always been interesting. It's always been a question. We don't check for functionality we check for connectivity. So the process is to make sure that every connection is made.

It feels that the Functionality is the base for the connectivity?

No, I see what you're saying but no.

As far as this diagram goes, we have two recursive processes for SBWE and PEP. For PEP test steps are created and SBWE test steps are revise? What is your review of it?

I agree with it.

What is the role of the T-E/E Integrator?

We have global set of jobs. I then have to transfer those into the plant set of steps. They are global set of jobs which I have to put it into the plant. They don't use Cascade very much.

He deals with the RDE Electronics. It uses the same EDIABAS Jobs but it uses an ASCII database. It has been adapted for the rolling road.

Is 926 start of production?

Its not very clear. It makes no sense at all. That's not start of production because you have commissioning in there.

Would construction be assembly?

No because SOP means that everything is finished. By the time we get to SOP we should have 100% success rate on the vehicles.

When your at commission, your not 100% ready.

What is the diff between 923 and 924?

I don't see a difference. Not very clear. No idea.

How these sheets are communicated across the organization?

Once a year. They are a good guide in general but they are looked at if they need to be updated. I have been here for many launches. There is paper and then there is reality. We don't follow the sheets.

Are the process right?

Yes they would be similar but by time we know who we need to talk to.

How do ppl know their responsibility?

I think this business is quite flexible slot in and to do what is necessary. Very few ppl who look at these process sheets would not look at them again.

What is your recommendation for improvement?

They should be rationalized and more diagrammatic in terms of build phases and development.

Can you tell me a bit about FITZ?

Big building, big canteen. Our dept is based in the Fitz. I only have to deal with the TI 53.

So Plant 0 is Fitz?

No Plant 0 is Munich. Fitz is the multiple disciplines.

What would the diff 0 and Fitz?

0 is an assembly plant. FITZ is offices.

Fitz is where all the planning happens?

Yes.

What is TeMo?

No idea

Do you know much abt the TEQ Leitfaden?

No.

According to 918, what is your understanding here?

Basically, we are looking at the TVG and we have a set of test sequences. We then have TVG have times and we look at times and whether we can improve the time. I look at the three pieces of equipment. Keep it 4 mins per station.

If this PEP, would you be create TVGs?

No they are done in central. It is centrals responsibility. It is easier for LU because it runs over three plants.

We should all follow Leipzig, but its not the case.

The Testing Sequence is done in CASCADE??

Only in Mo Test.

Is that where you would improve your TVGs?

Yes.

We are not always sure of the parameters for example like for the brakes. As we learn about the cars, we adjust that.

922, conduct intermediate Fitz Plant? Is this handing over the plans to a specific plant?

Yes that is handing over from Michael to PI (Patrick L3 and Markus S for LU).

Once they get that from FITZ then whats next?

We have a test plan which is basically all the tests and all the test stations and that is where the tests appear in the plant.

923?

No .

What are ZMDs?

Same as TVGs.

I work very differently to others. They seem to have test stations whereas I have a lot of mechanical responsible.

The Sub leader is for the equipment to be in the plant. (Integrating the facility) The process specialist role is for putting up the test sequences.

His area is more general whereas this is for E/E.

Lots of micro changes are made so they have istep where they all put all the changes into a bundle. Make that up to date.

IStep 3-500, you may have 503 or 504 to show small changes.

Basically, maturity of the software on the vehicle which is I-Steps.

For engines and Gearbox does Istep but through MSF.

How do you know about the microchanges?

There is a launch department. From there it is issued.

KMG and PUMA is similar to MSF?

It doesn't fit into that. That is something that Patrick would know.

Role : Functional - Process Specialist (2 of 2)

Person: FPS-P2

Date:

Can you summarize you job duties?

Involved in ECOs Development and involved in both PEP and SBWE.

Wasn't sure about being both a Functional Specialist and Process Specialist.

Have long have you been performing these duties?

4 years

Does this rich picture diagram make sense to you?

Yes it is excellent and it will be useful to communicate with the organization with this sort of Rich Picture Diagrams.

How is this process different to the vehicle build for the SBWE planning process?

n.r.

Are you completely aware about the Process Sheets (9_1-9_2)?

No never seen them

How useful are these Process Sheets? (Why is that?)

N/A

Do you understand the planning process of PEP and SBWE?

n.r.

What is your role in the PEP and SBWE planning process?

n.r.

Are you aware that a Project/ Plant Functional Specialist exist?

Yes

How do plants communicate changes?

This FS documents changes during SB/WE and sends them once every month.

Across the organization how is this process sheet communicated? How do people involved in this process know their responsibility?

Not applicable

Do you think there can be improvements in the communication of these process sheets or process? What is your recommendation?

n.r.

Can you explain the BUZ Factor?

No

Can you explain the INPA Script?

They are global scripts but does not know how changes are communicated in the INPA script. Not sure if the scripts are Plant level or Organisation level.

Who is responsible for communicating the SB/WE changes?

The Functional Specialist informs the Process Integrator and the PI then communicates with Munich to inform the changes.

Peter D. Stanner

Role: Process Owner / Process Integrator Project - LU

Interview:1-2

Person: PI-PR3-1

Date: x

Can you summarize you job duties?

EE Process Integrator also who has to commission processes (SW, Coding, Initialization, Control Unit is assembled in the car etc.)

Assembly Test, Structure Planning,

Evaluating and Error planning

Have long have you been performing these duties?

May 2011

How are you involved in the PEP or SB/WE planning process?

In PEP but not in SBWE

What are your responsibilities?

Mainly Project Management

Are there communication issues here in general?

It is difficult to read and it is just a checklist for him looking at the outputs.

Can you explain the steps or the starting process?

n.r.

Can you explain a little about the Facht Team?

There is a FT for each part i.e. coding, testing etc

PS and FS are a part of the FT also.

Each plant has its own FT

Munich however is the central FT.

How is this process different to the vehicle build for the SBWE planning process?

Maybe SBWE does not need to assess TVGs

1 Process Integrator for the whole SBWE Process

However, in PEP there is a PI for each product.

Could you please explain the Process Sheets to me?

n.r.

How did you validate the planning process? (Meaning how did you know that this is the sequence?)

The output of each step validates the process described in the Excel Sheets.

How did you know whose responsibility it is at each step?

Best Practice or experience

913 is it more setting the testing and commissioning the schedule?

No, it is an early phase which discusses general features on the car

Also what are these :

Bestätigung Zielrahmen and Bestätigung Markteinführung & Prozess-Sicherheit and FPL der TMO and LeLe?

LeLe is Lessons Learned.

FPL de TMO is Assembly Project Leader.

Bestatigung Markteinfuhrung & Prozess-Sicherheit – Bringing the Product to the Market and securing the Process(Synchropoint)

Bestätigung Zielrahmen – Confirmation of the Target (Synchropoint)

914?

In 914, it's the last time to make changes. It is a detailed output and shows if there are any influences on the development.

917 what do you mean by Test Knowledge is this PL (Test Sequence)

Yes and PU

918, what do you mean Setting up Test Sequence and Core TVGs and in the previous step it was Test Knowledge? Whats the difference? Shouldn't the FS and PS be present in this task?

Test Sequence is setting the sequence of the A Test B Test F1 etc. Including the position. CASCADE is also implemented into the plant.

Whats the difference between 918 and 919?

918 is implementing into a plant and 919 is executing that run.

920 why is the FS not assisting the PS in this task?

What is the output of this task? Is transferring from Plant 0 to Plant

921? Why does this succeed 09218920? Why is the FS not present?

To check if it works properly in the plant implemented.

922 is a bit confusing. Is this the handover to the plant? What is the output here?

(Because 923 is applying the plans to the plant) Plant Preparation, changes being brought into the Plant. At the same time, FITZ is working and updating itself.

923 the steps are 922 and 925?

923 is implemented into all plants.

What are ZMDs?

Is where all TVGs are stored.

924 is validating the course of commissioning in all plants? The steps are 923 and 926?

Will check and let me know

925 is a sub process of 924?

n.r.

What is the diff between 925 and 926?

n.r.

What is inbetriebnameplan?

Development Plan.

What is PQM and QC?

Prod. Quality Management and Quality Control

926?

Is Problem Management and Synchronization

Across the organization how is this process sheet communicated?

n.r.

How do people involved in this process know their responsibility?

Peter D. Stanner

Experience will help understand responsibility

Do you think there can be improvements in the communication of these process sheets or process? What is your recommendation?

It should be readable as 40-50% is still in German. Hard for German to read so how will it be easy for English native read it.

Can you explain the BUZ Factor?

BUZ Factor is a play of financial numbers. It is about the finances. How many TVGs and how much is it going to cost. (Money talk)

What are INPA scripts?

They are global scripts which are generalized for all vehicles. Whereas you have Cascade which is catered to one VIN/Order number. INPA are based on your SGBDs

What is PUMA and KMG?

PUMA is a Master List which is updated every 2 weeks. It includes all the parts to be added to the vehicle. The PI deploys this info.

KMG Not sure

What are GAMs?

GAMs is a Change Management System

Which are not included in the process sheets and will be updated.

NOTES:

927 is Assembly, handing over to the Plant Assembly, SOP would have begun already.

T-E/E Integrator is more about knowledge transfer

Process Integrator communicates with EE Integrator. The EE Integrator is responsible for the overall EE Functions.

To get changes from Audit

To get Generic Synchroplan

Doubts:

Doesn't know where SOP fits in.

Sequence 922-925

Changes:

Remove SBWE from the Design

Need to check if there is a PS for SBWE

Peter D. Stanner

Role: Plant Process Integrator LU - Project

Interview:2-2 (Skype)

Date: 12/10/2012

After the initial interview we had this is the updated version of the Rich Picture Diagram portraying the T-E/E 9.1 Plan and Validate EE Production Planning Process. Let us go through them and may be you could provide feedback about this diagram.

Yes sure.

Ok firstly, it is not Facht Team, its Fach Team.

Oh ok thank you for pointing that out.

The Process Integrator being selected and kicking off the project is fine. After that the schedule is developed and then the Requirements Catalogue is created.

Maybe make this the Requirements Catalogue a bit more specific it sounds vague.

Yes I will do that.

The BUZ Factor, I think the T-E/E Integrator is not present here and the Fach Team provides input not get the output here. For example, the Fach Team may say we need 5 million Euros to install the Rolling Road in Assembly and that is given to them.

I see, but I was following the Process sheets, if you look at the process step 02918915 Create The BUZ Factor, the T-E/E Integrator and the Fach Team are receiving the output.

Ah yes, I am wrong sorry. But I think you should change the T-E/E Integrator to Vehicle Project so that it states that this info is going to the project.

Sure I shall do that. Ok then we have the E/E Test Plan which is the Inbetriebnahmeplan, it has been renamed from Commissioning schedule to clarify the meaning of it, as previously, Commissioning Schedule is a very heavy word in English.

Yes that is fine.

Then the Process Specialist and Function Specialist within the Fach Team are creating and revising the test content, INPA Scripts and revising the Test Sequence.

Yes that is fine.

Once that happens, then the plans are approved from the FIZ and handed over to the affected plants.

The FIZ is not actually an approval no one signs off on it. It is just Testing and Finalizing the E/E Test Plans before it is implemented.

Also the Cross Plant Synchronization is actually parallel with the Handover. It may happen before but it is better to show it parallel than after.

Yes I will do that. Anything else you would like to point out.

No the rest is fine.

Ok let us move to the Process Models now. Here we have the entire high level view of the BPMN.

Yes it is fine.

Let me open the first step on a task level. Here is 02918910 Appoint Process Integrator, what are your views on this?

You have portrayed the Arbeitskreis (AK) members separately, they are actually one group not two separate roles. All the managers are belong to the AK.

Where does this Project Start letter come from?

It comes from the LU project from the AK who have had it.

So is it a trigger?

I am not sure.

Anything else you would like to point out here?

No, the rest is fine.

Ok let us move to the next step which is 02918911 Project Kick Off. Here the Process Integrator is taking control of the Project by developing a schedule and setting the project team.

Ok firstly, the Fach Team Process Integration and Project/Plant Process Integrator are the same group of individuals.

You can delete the Arbeitskreis Process Planner and maybe just have the AK in general.

The FPL der TMO sends information into this step.

Also the AK is not involved here at all.

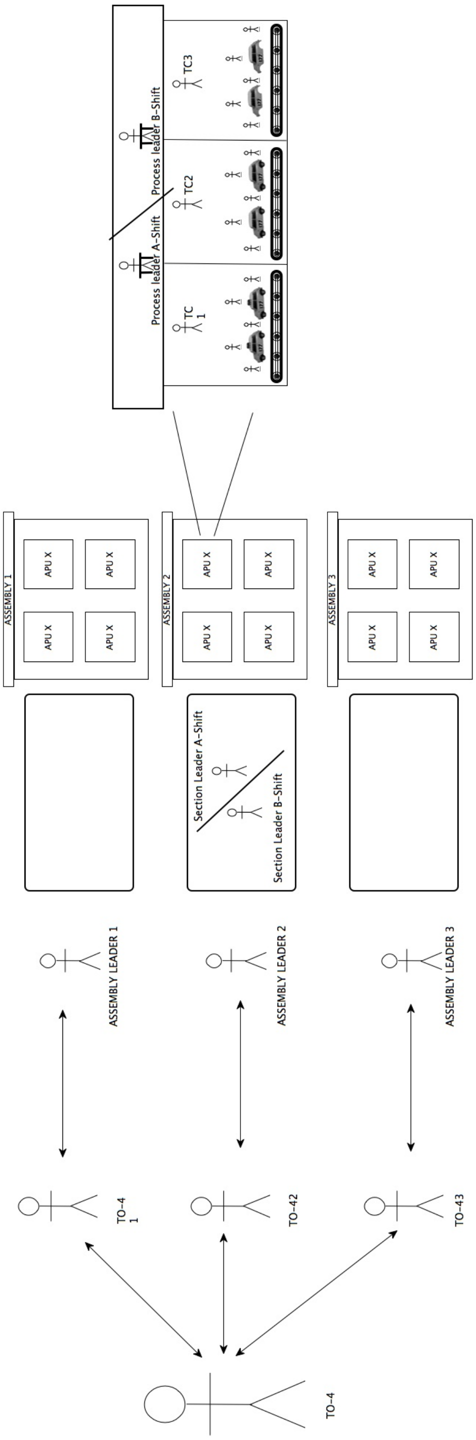
But if you look at the process sheets, the Arbeitskreis is involved here in this step.

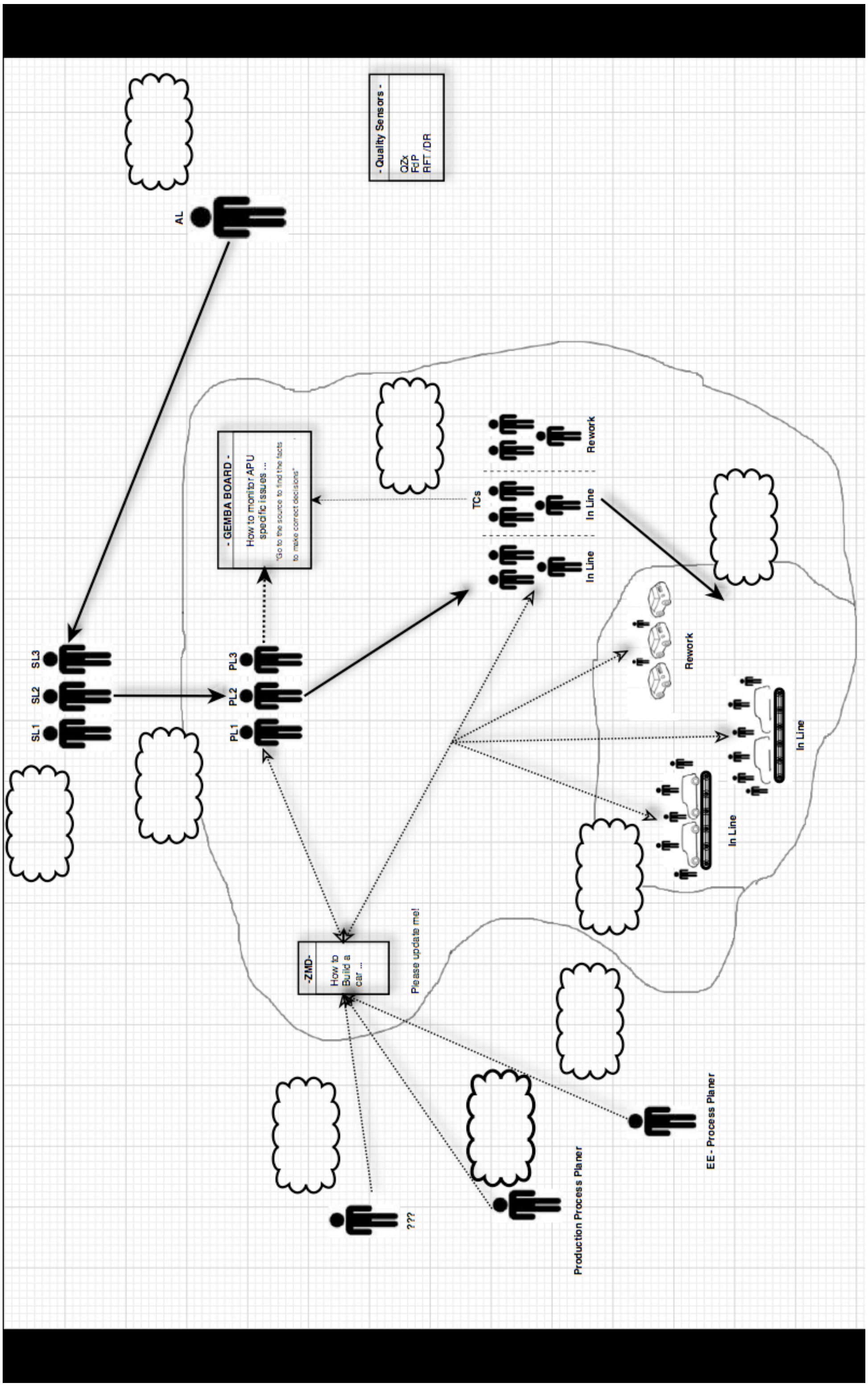
Yes your right. I made a mistake.

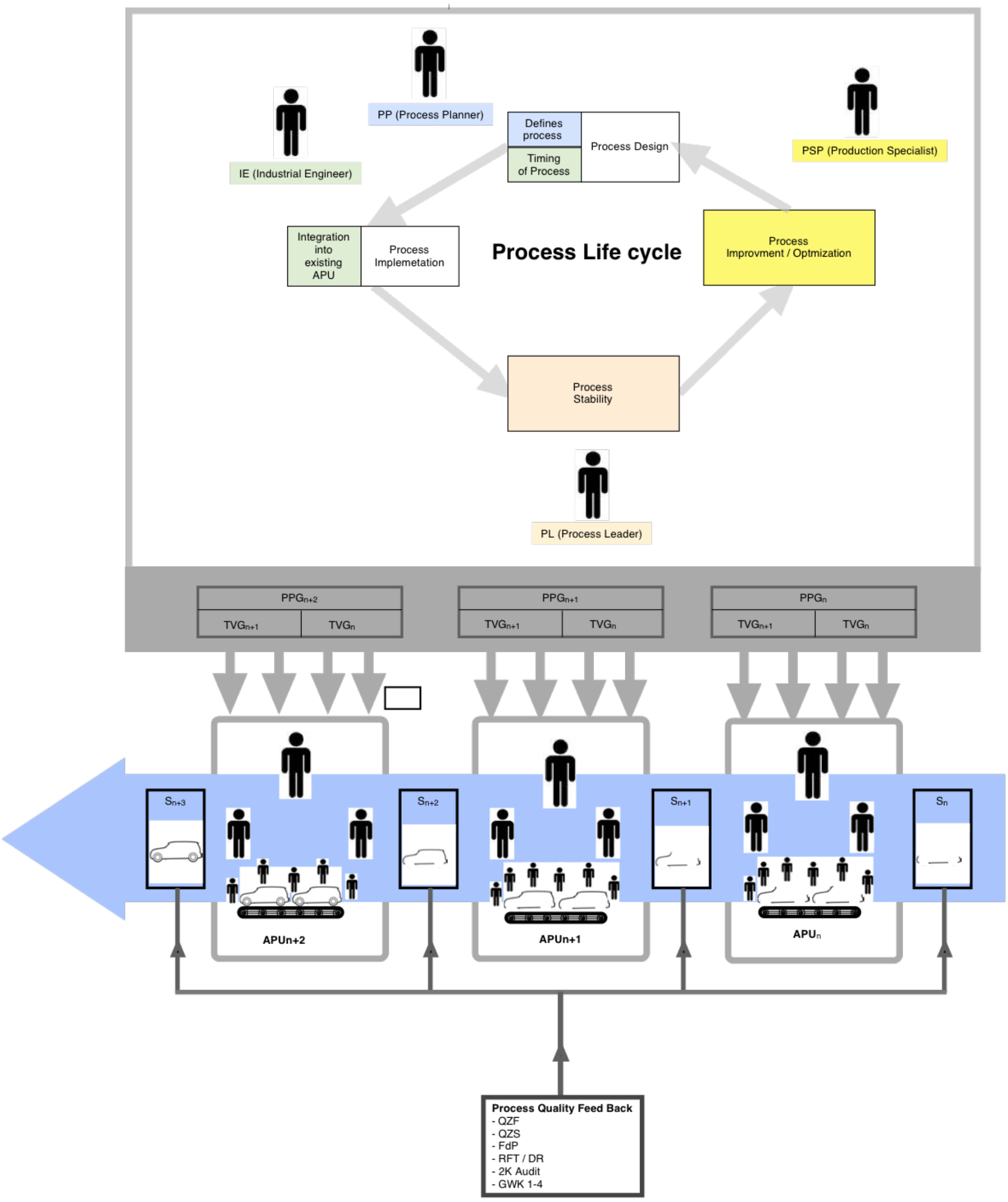
The rest looks fine.

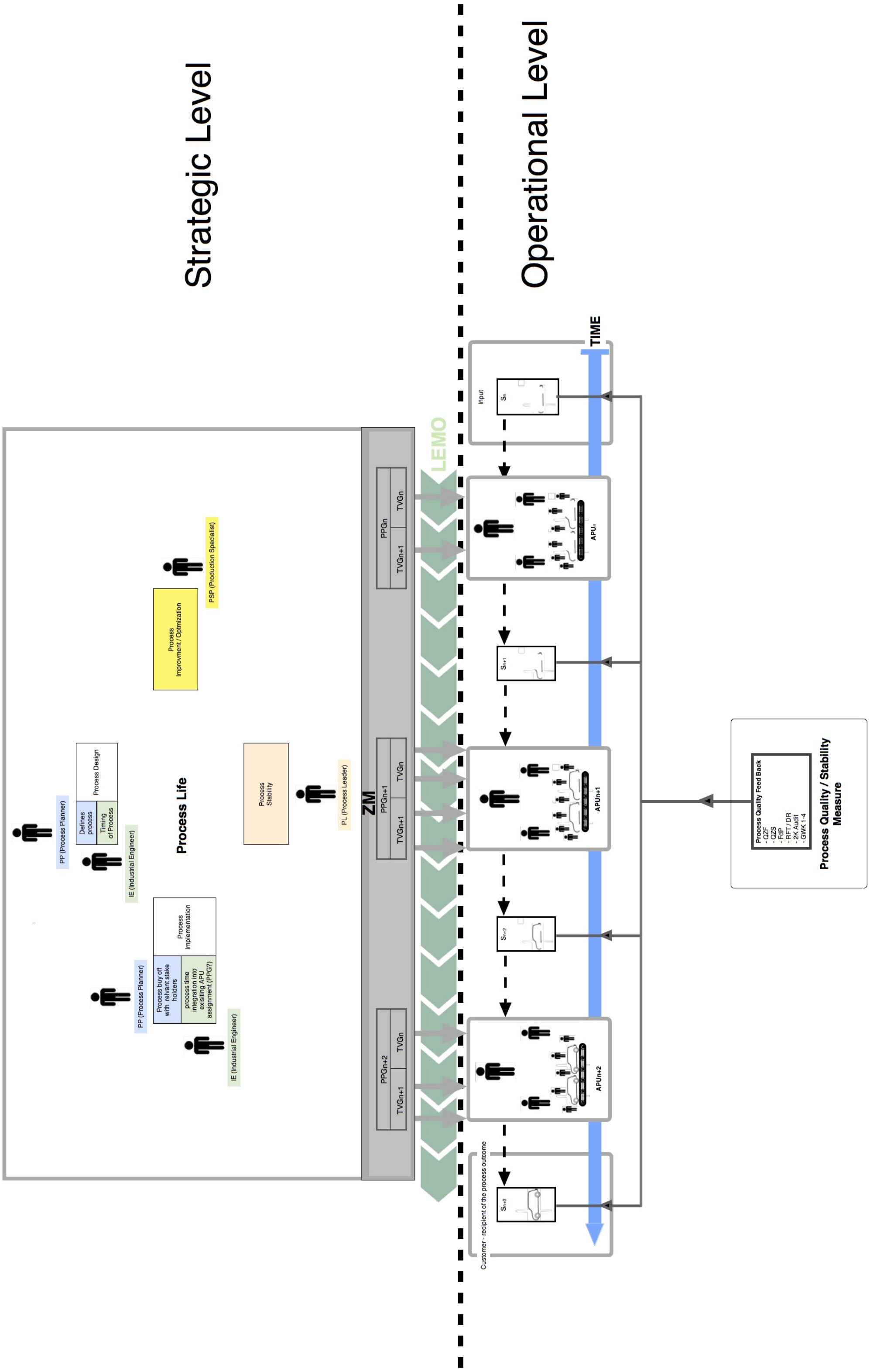
C. Vehicle test system overview

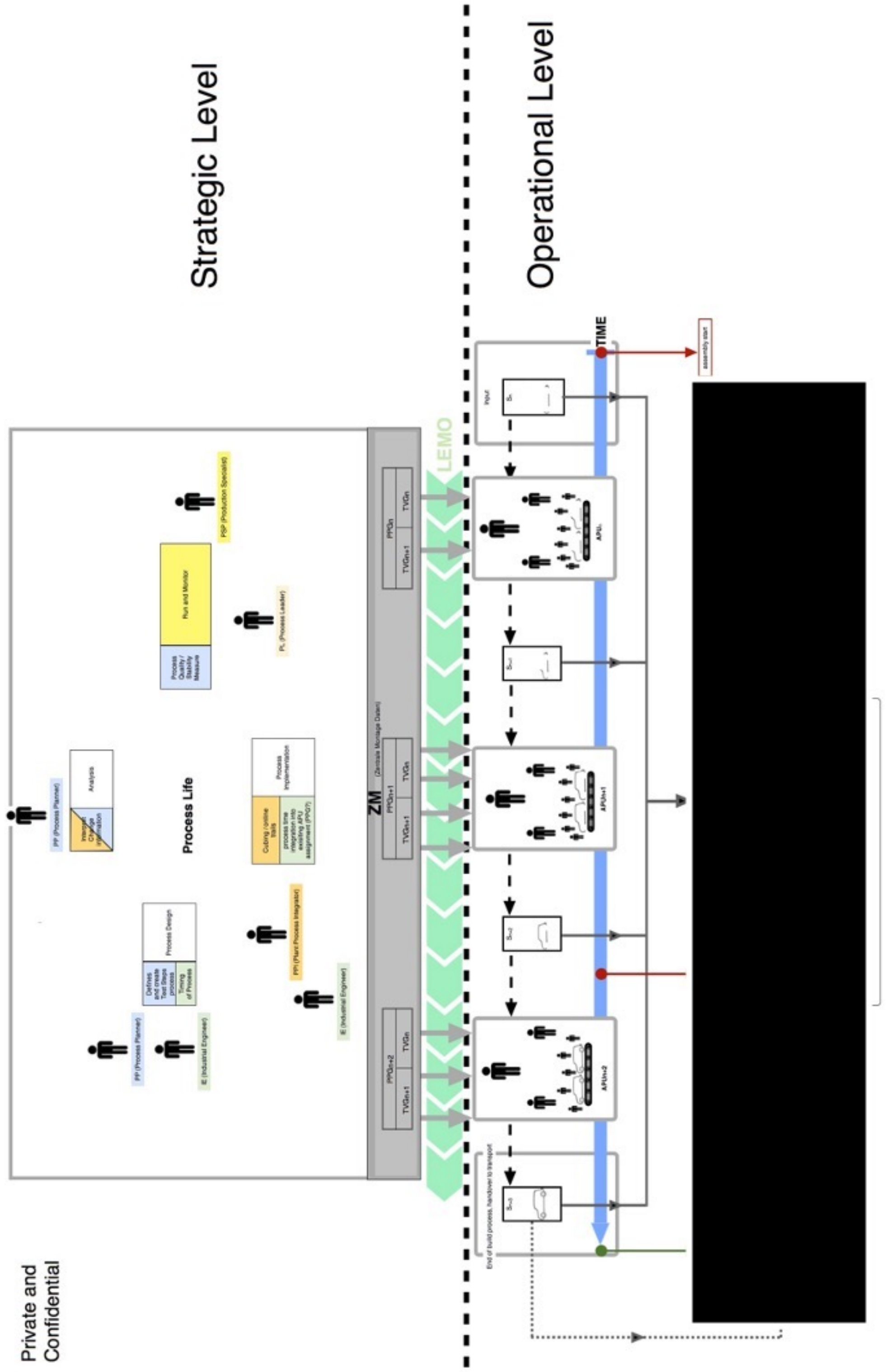
D. Rich Picture Diagrams

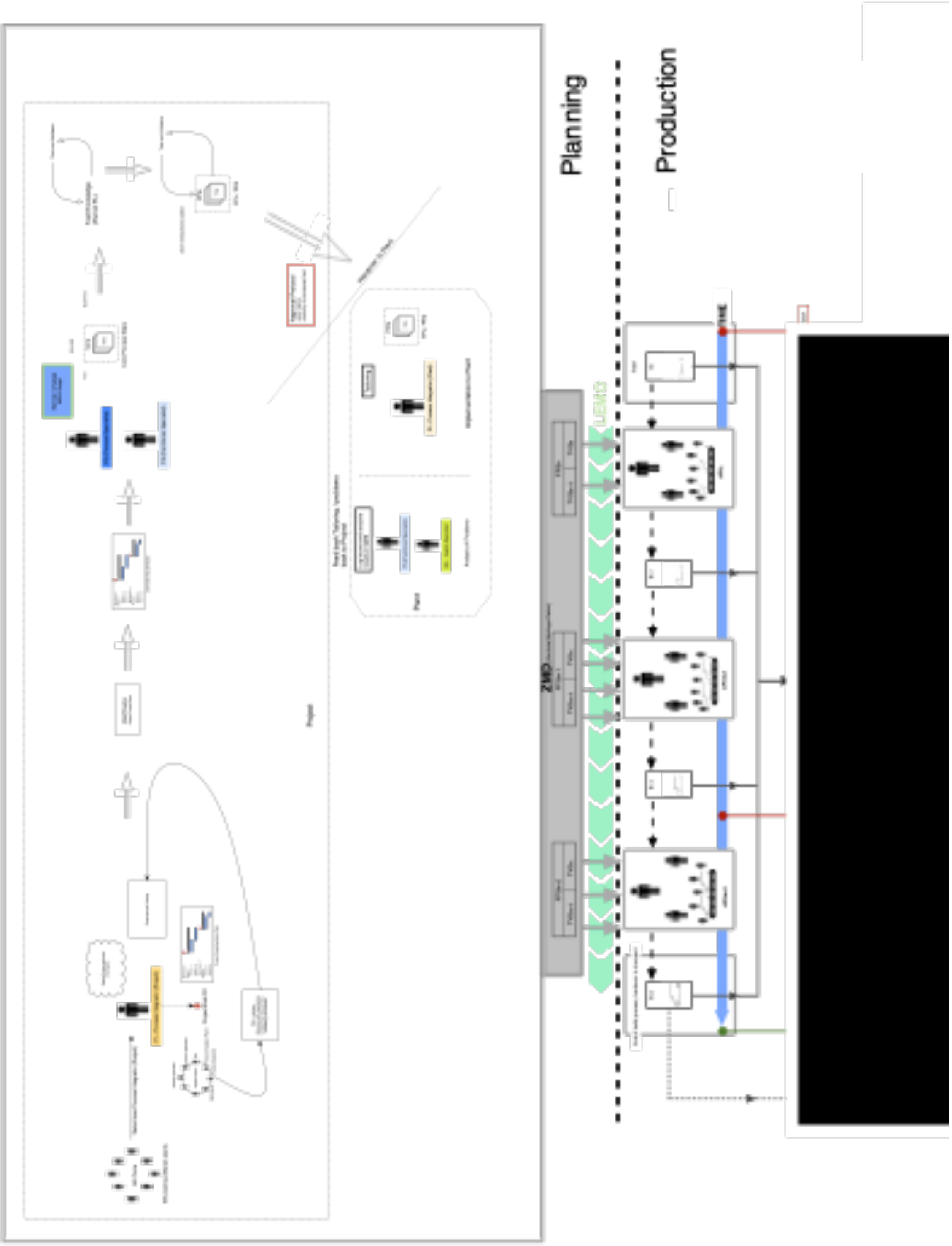

Process leader A-Shift
Process leader B-Shift
TC 1
TC2
TC3
ASSEMBLY 1
ASSEMBLY 2
ASSEMBLY 3
APU X
Section Leader A-Shift
Section Leader B-Shift
ASSEMBLY LEADER 1
ASSEMBLY LEADER 2
ASSEMBLY LEADER 3
TO-41
TO-42
TO-43
TO-4

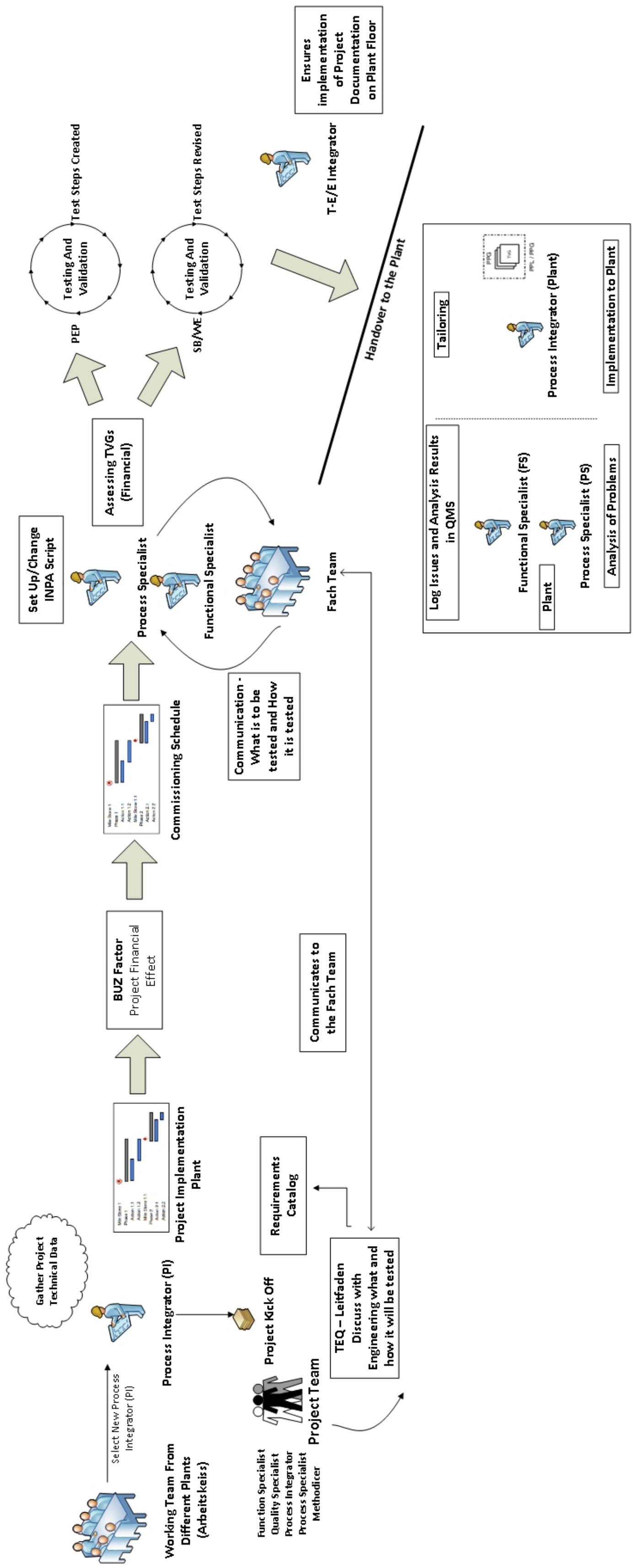

AL
- Quality Sensors -
QZx
FdP
RFT /DR
SL3
SL2
SL1
PL3
PL2
PL1
- GEMBA BOARD -
How to monitor APU specific issues ...
"Go to the source to find the facts to make correct decisions"
TCs
In Line
In Line
Rework
Rework
In Line
In Line
-ZMD-
How to Build a car ...
Please update me!
???
Production Process Planer
EE - Process Planer

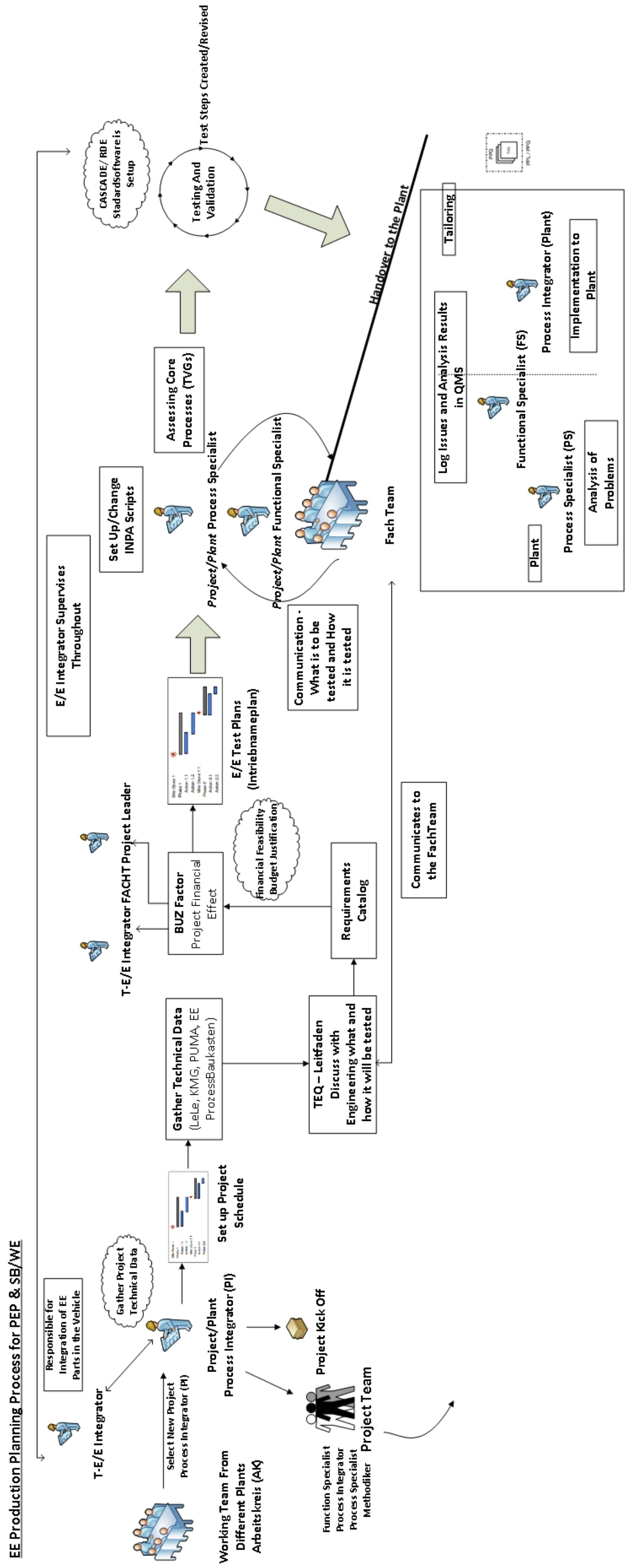

PP (Process Planner)
IE (Industrial Engineer)
PSP (Production Specialist)
Defines process
Timing of Process
Process Design
Integration into existing APU
Process Implemetation
Process Life cycle
Process Improvment / Optmization
Process Stability
PL (Process Leader)
PPGn+2
TVGn+1
TVGn
PPGn+1
TVGn+1
TVGn
PPGn
TVGn+1
TVGn
Sn+3
Sn+2
Sn+1
Sn
APUn+2
APUn+1
APUn
Process Quality Feed Back
- QZF
- QZS
- FdP
- RFT / DR
- 2K Audit
- GWK 1-4

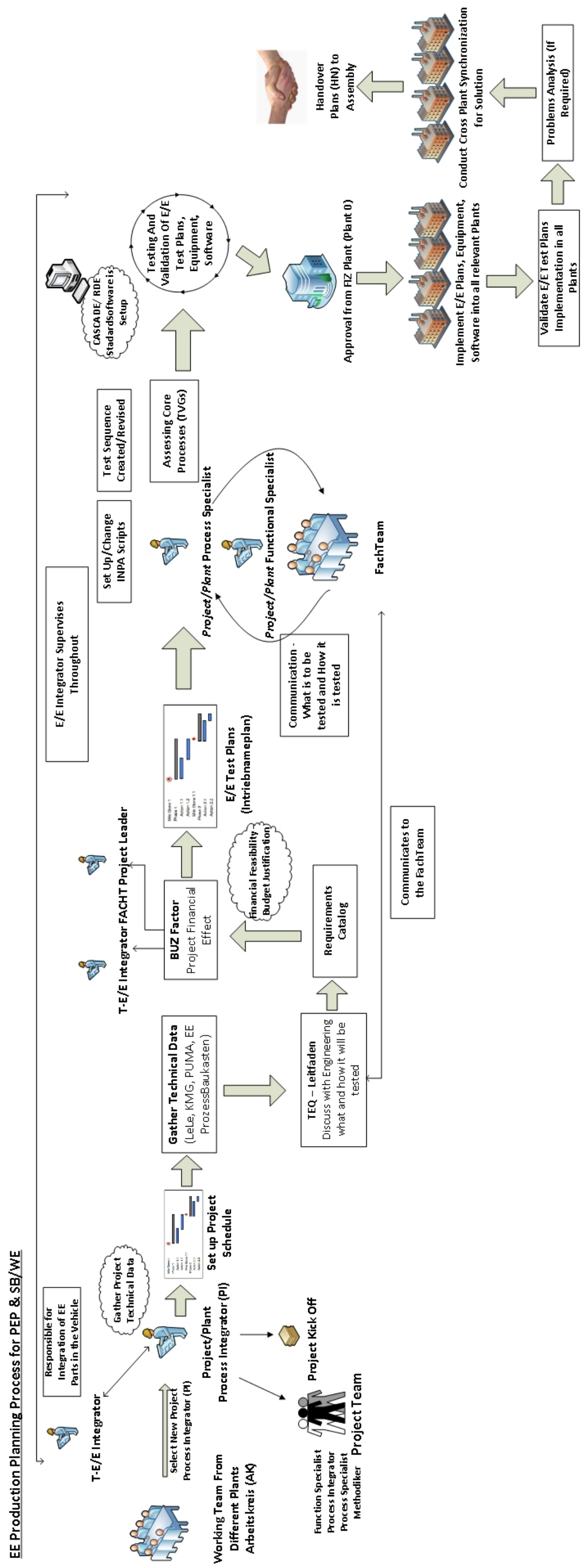

Strategic Level
Operational Level
Process Life
ZM
LEMO
TIME
Process Quality / Stability Measure


Strategic Level
Operational Level
Private and Confidential
Process Life
ZM
LEMO
TIME

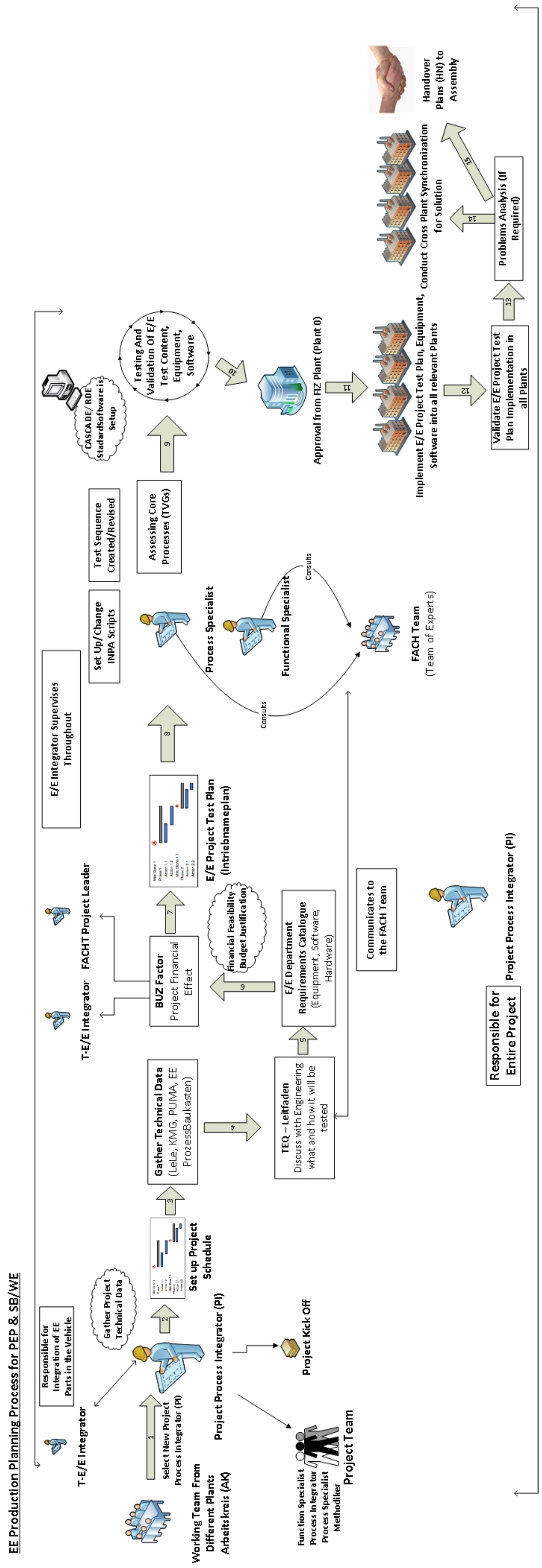

Planning
Production

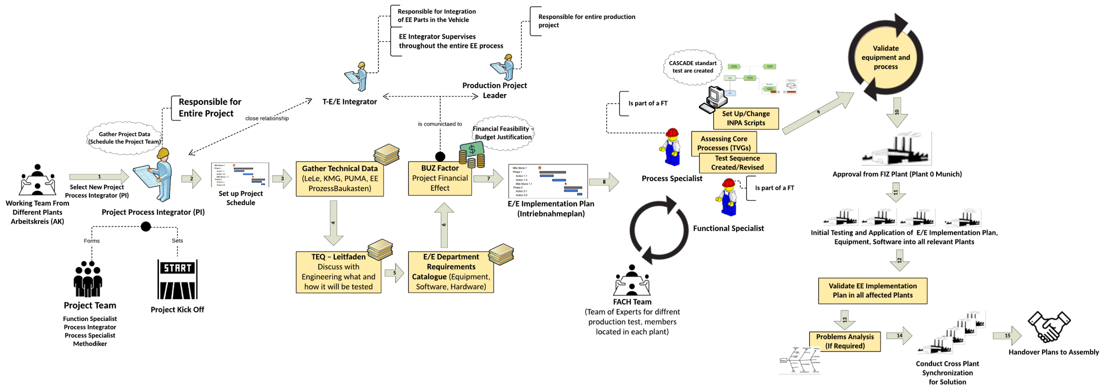

Working Team From Different Plants (Arbeitskeis)
Select New Process Integrator (PI)
Gather Project Technical Data
Process Integrator (PI)
Project Kick Off
Project Team
Function Specialist
Quality Specialist
Process Integrator
Process Specialist
Methodicer
TEQ – Leitfaden Discuss with Engineering what and how it will be tested
Requirements Catalog
Project Implementation Plant
BUZ Factor
Project Financial Effect
Commissioning Schedule
Communicates to the Fach Team
Communication - What is to be tested and How it is tested
Set Up/Change INPA Script
Process Specialist
Functional Specialist
Fach Team
Assessing TVGs (Financial)
PEP
Testing And Validation
Test Steps Created
SB/WE
Testing And Validation
Test Steps Revised
T-E/E Integrator
Ensures implementation of Project Documentation on Plant Floor
Handover to the Plant
Log Issues and Analysis Results in QMS
Functional Specialist (FS)
Plant
Process Specialist (PS)
Analysis of Problems
Tailoring
Process Integrator (Plant)
Implementation to Plant


EE Production Planning Process for PEP & SB/WE
Responsible for Integration of EE Parts in the Vehicle
T-E/E Integrator
Select New Project Process Integrator (PI)
Working Team From Different Plants Arbeitskreis (AK)
Gather Project Technical Data
Project/Plant Process Integrator (PI)
Project Kick Off
Project Team
Function Specialist
Process Integrator
Process Specialist
Methodiker
Set up Project Schedule
Gather Technical Data (LeLe, KMG, PUMA, EE ProzessBaukasten)
TEQ – Leitfaden Discuss with Engineering what and how it will be tested
T-E/E Integrator FACHT Project Leader
BUZ Factor Project Financial Effect
Requirements Catalog
Financial Feasibility Budget Justification
Communicates to the FachTeam
E/E Test Plans (Intriebnameplan)
E/E Integrator Supervises Throughout
Communication - What is to be tested and How it is tested
Set Up/Change INPA Scripts
Project/Plant Process Specialist
Project/Plant Functional Specialist
Fach Team
Assessing Core Processes (TVGs)
Testing And Validation
CASCADE/ RDE StadardSoftware is Setup
Test Steps Created/Revised
Handover to the Plant
Plant
Process Specialist (PS)
Analysis of Problems
Functional Specialist (FS)
Log Issues and Analysis Results in QMS
Process Integrator (Plant)
Implementation to Plant
Tailoring

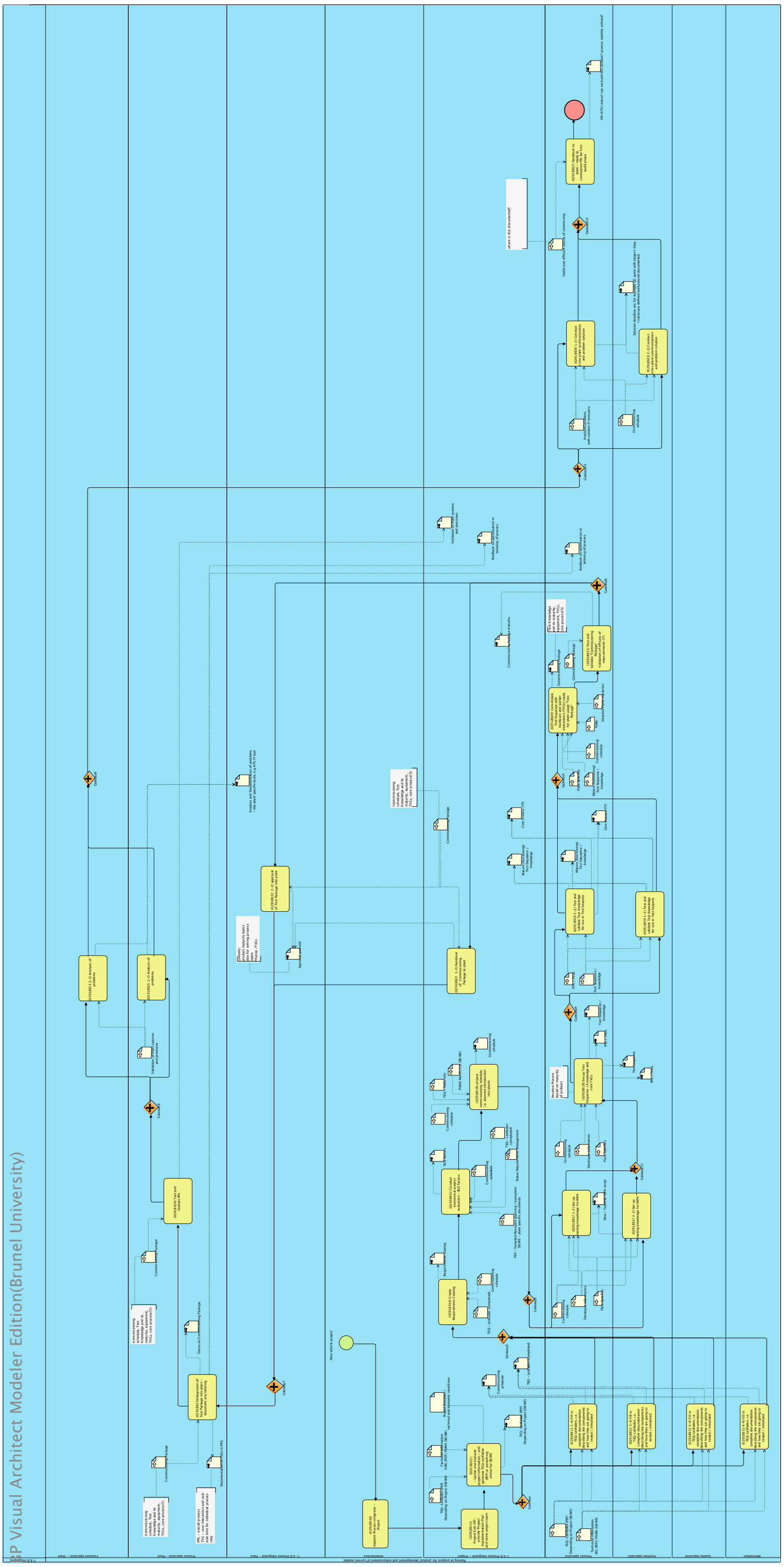


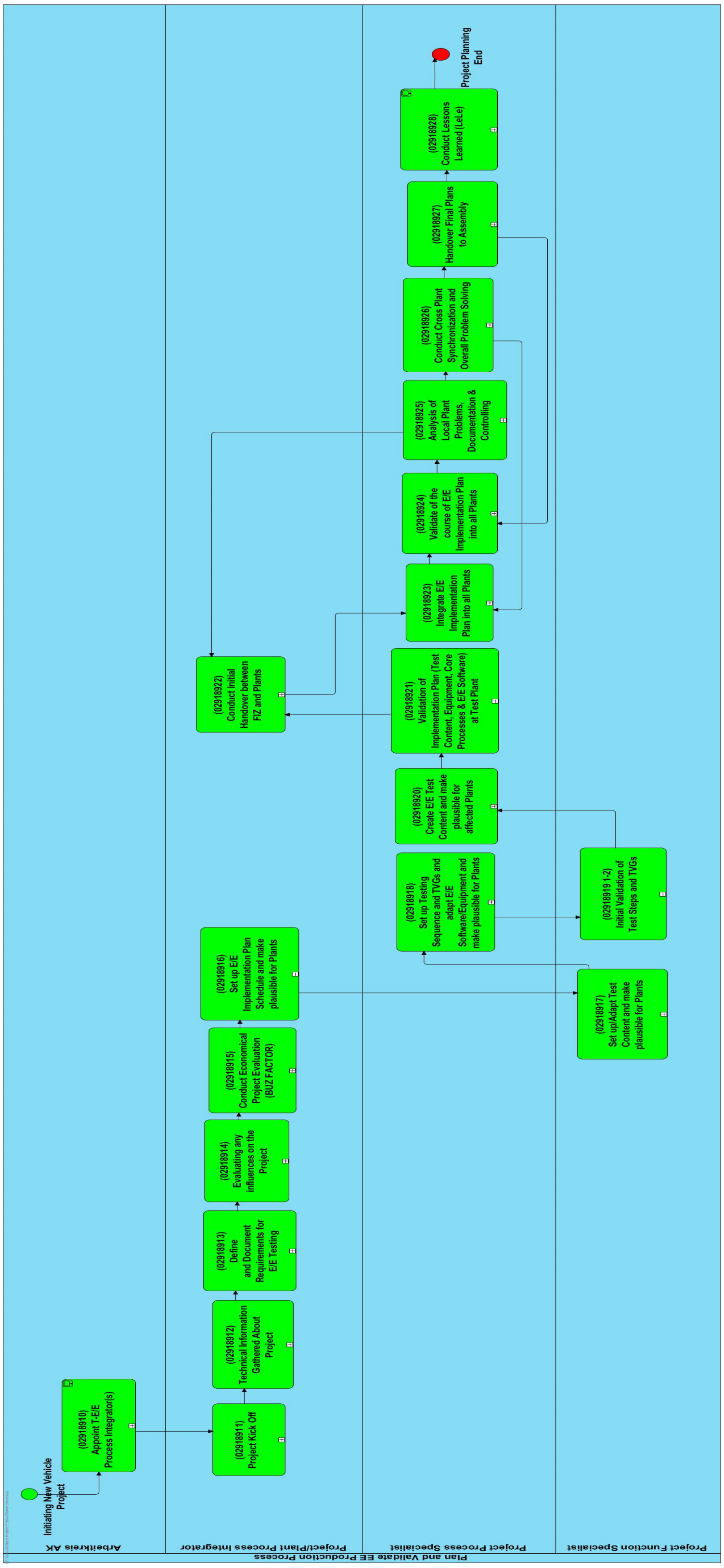
EE Production Planning Process for PEP & SB/WE
Responsible for Integration of EE Parts in the Vehicle
T-E/E Integrator
Working Team From Different Plants Arbeitskreis (AK)
Select New Project Process Integrator (PI)
Gather Project Technical Data
Project/Plant Process Integrator (PI)
Project Kick Off
Function Specialist
Process Integrator
Process Specialist
Methodiker
Project Team
Set up Project Schedule
Gather Technical Data (LeLe, KMG, PUMA, EE ProzessBaukasten)
TEQ – Leitfaden Discuss with Engineering what and how it will be tested
Requirements Catalog
T-E/E Integrator FACHT Project Leader
BUZ Factor Project Financial Effect
Financial Feasibility Budget Justification
E/E Test Plans (Intriebnameplan)
Communicates to the FachTeam
E/E Integrator Supervises Throughout
Communication - What is to be tested and How it is tested
Set Up/Change INPA Scripts
Test Sequence Created/Revised
Project/Plant Process Specialist
Project/Plant Functional Specialist
FachTeam
Assessing Core Processes (TVGs)
CASCADE/ RDE StadardSoftwareis Setup
Testing And Validation Of E/E Test Plans, Equipment, Software
Approval from FIZ Plant (Plant 0)
Implement E/E Plans, Equipment, Software into all relevant Plants
Validate E/E Test Plans Implementation in all Plants
Problems Analysis (If Required)
Conduct Cross Plant Synchronization for Solution
Handover Plans (HN) to Assembly


EE Production Planning Process for PEP & SB/WE
T-E/E Integrator
Responsible for Integration of EE Parts in the Vehicle
Gather Project Technical Data
Working Team From Different Plants Arbeitskreis (AK)
1
Select New Project Process Integrator (PI)
Project Process Integrator (PI)
2
Set up Project Schedule
3
Gather Technical Data (LeLe, KMG, PUMA, EE ProzessBaukasten)
4
TEQ – Leitfaden Discuss with Engineering what and how it will be tested
5
E/E Department Requirements Catalogue (Equipment, Software, Hardware)
6
Financial Feasibility Budget Justification
BUZ Factor Project Financial Effect
T-E/E Integrator
FACHT Project Leader
7
E/E Project Test Plan (Intriebnameplan)
E/E Integrator Supervises Throughout
8
Communicates to the FACH Team
Function Specialist
Process Integrator
Process Specialist
Methodiker
Project Team
Project Kick Off
Process Specialist
Functional Specialist
Consults
Consults
FACH Team (Team of Experts)
Set Up/Change INPA Scripts
Test Sequence Created/Revised
Assessing Core Processes (TVGs)
9
CASCADE/ RDE StadardSoftware is Setup
Testing And Validation Of E/E Test Content, Equipment, Software
10
Approval from FIZ Plant (Plant 0)
11
Implement E/E Project Test Plan, Equipment, Software into all relevant Plants
12
Validate E/E Project Test Plan Implementation in all Plants
13
Problems Analysis (If Required)
14
Conduct Cross Plant Synchronization for Solution
15
Handover Plans (HN) to Assembly
Responsible for Entire Project
Project Process Integrator (PI)

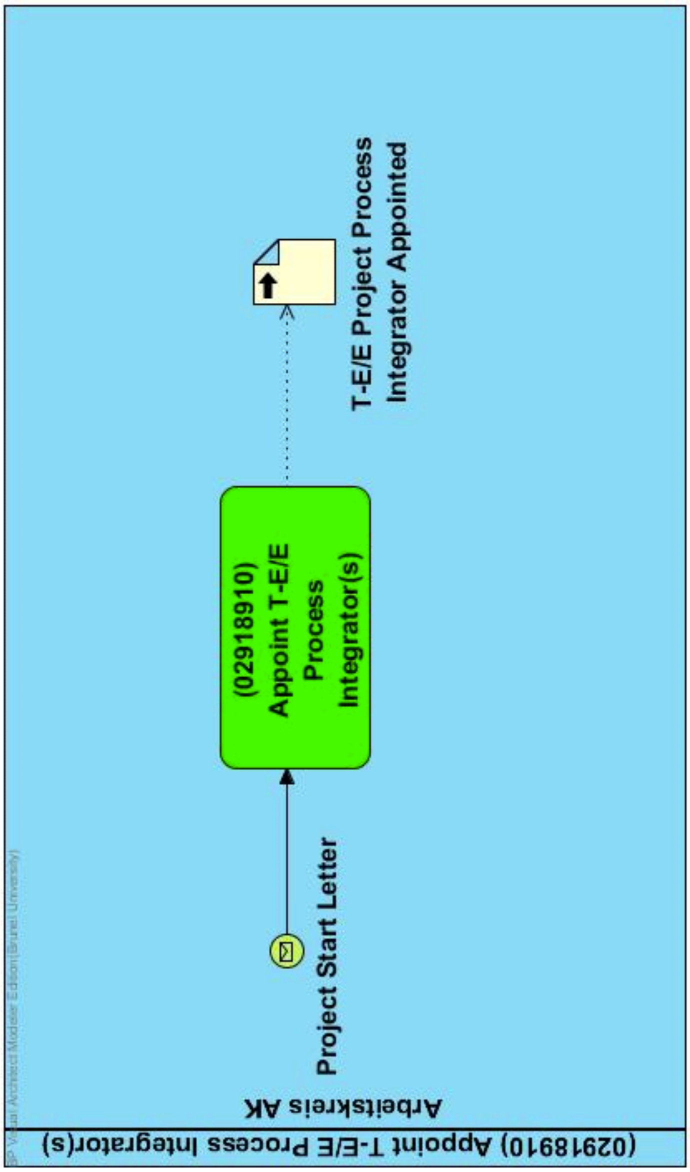

Responsible for Integration of EE Parts in the Vehicle
EE Integrator Supervises throughout the entire EE process
Responsible for entire production project
T-E/E Integrator
Production Project Leader
Responsible for Entire Project
close relationship
is comunictaed to
Gather Project Data (Schedule the Project Team)
Financial Feasibility - Budget Justification
Working Team From Different Plants Arbeitskreis (AK)
1
Select New Project Process Integrator (PI)
Project Process Integrator (PI)
2
Set up Project Schedule
3
Gather Technical Data (LeLe, KMG, PUMA, EE ProzessBaukasten)
BUZ Factor Project Financial Effect
7
E/E Implementation Plan (Intriebnahmeplan)
8
4
6
TEQ – Leitfaden Discuss with Engineering what and how it will be tested
5
E/E Department Requirements Catalogue (Equipment, Software, Hardware)
Forms
Sets
Project Team
Function Specialist
Process Integrator
Process Specialist
Methodiker
START
Project Kick Off
CASCADE standart test are created
Is part of a FT
Set Up/Change INPA Scripts
Assessing Core Processes (TVGs)
Test Sequence Created/Revised
Process Specialist
Is part of a FT
Functional Specialist
FACH Team
(Team of Experts for diffrent production test, members located in each plant)
9
Validate equipment and process
10
Approval from FIZ Plant (Plant 0 Munich)
11
Initial Testing and Application of E/E Implementation Plan, Equipment, Software into all relevant Plants
12
Validate EE Implementation Plan in all affected Plants
13
Problems Analysis (If Required)
14
Conduct Cross Plant Synchronization for Solution
15
Handover Plans to Assembly

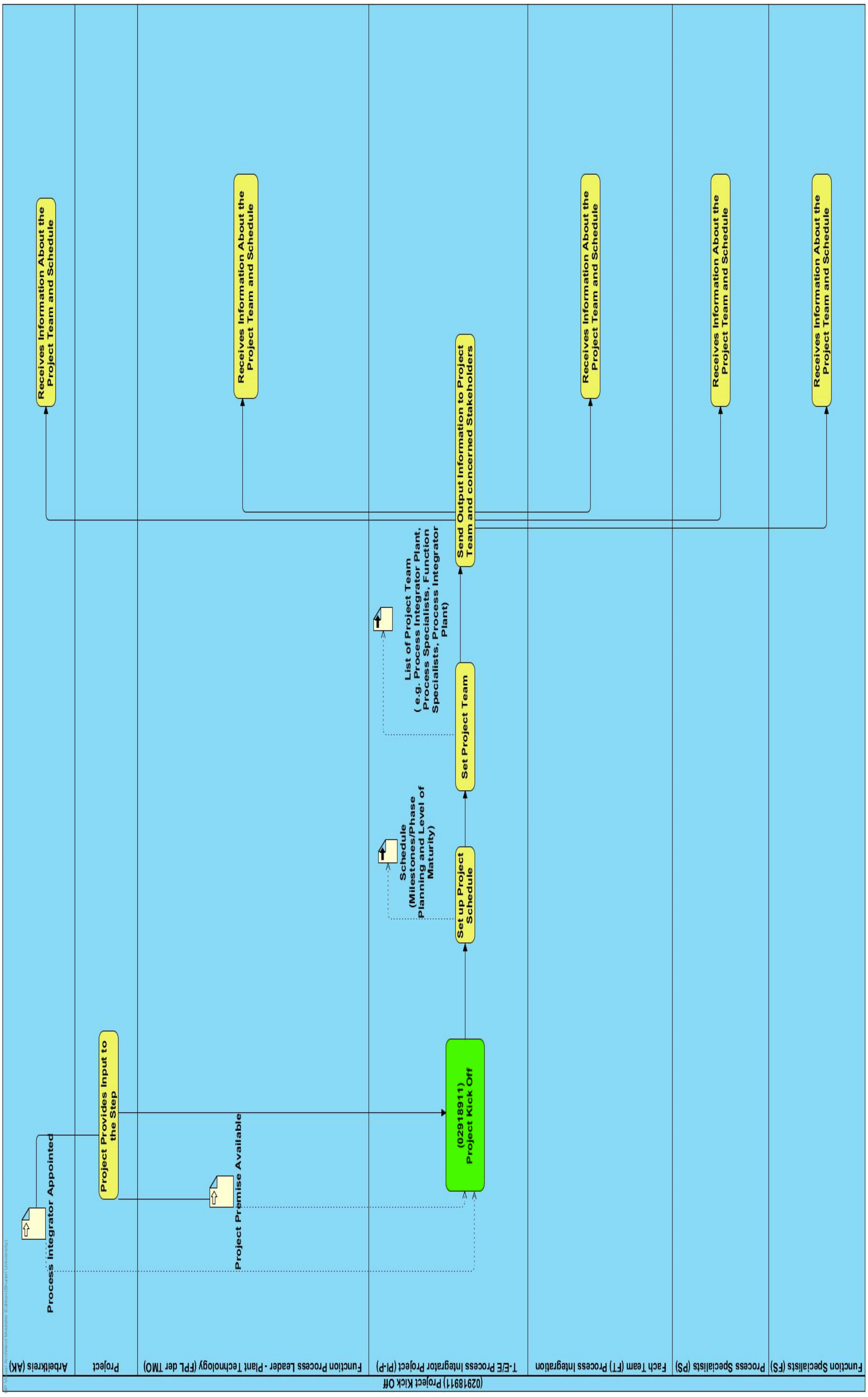
E. Ontologies Business Process Models

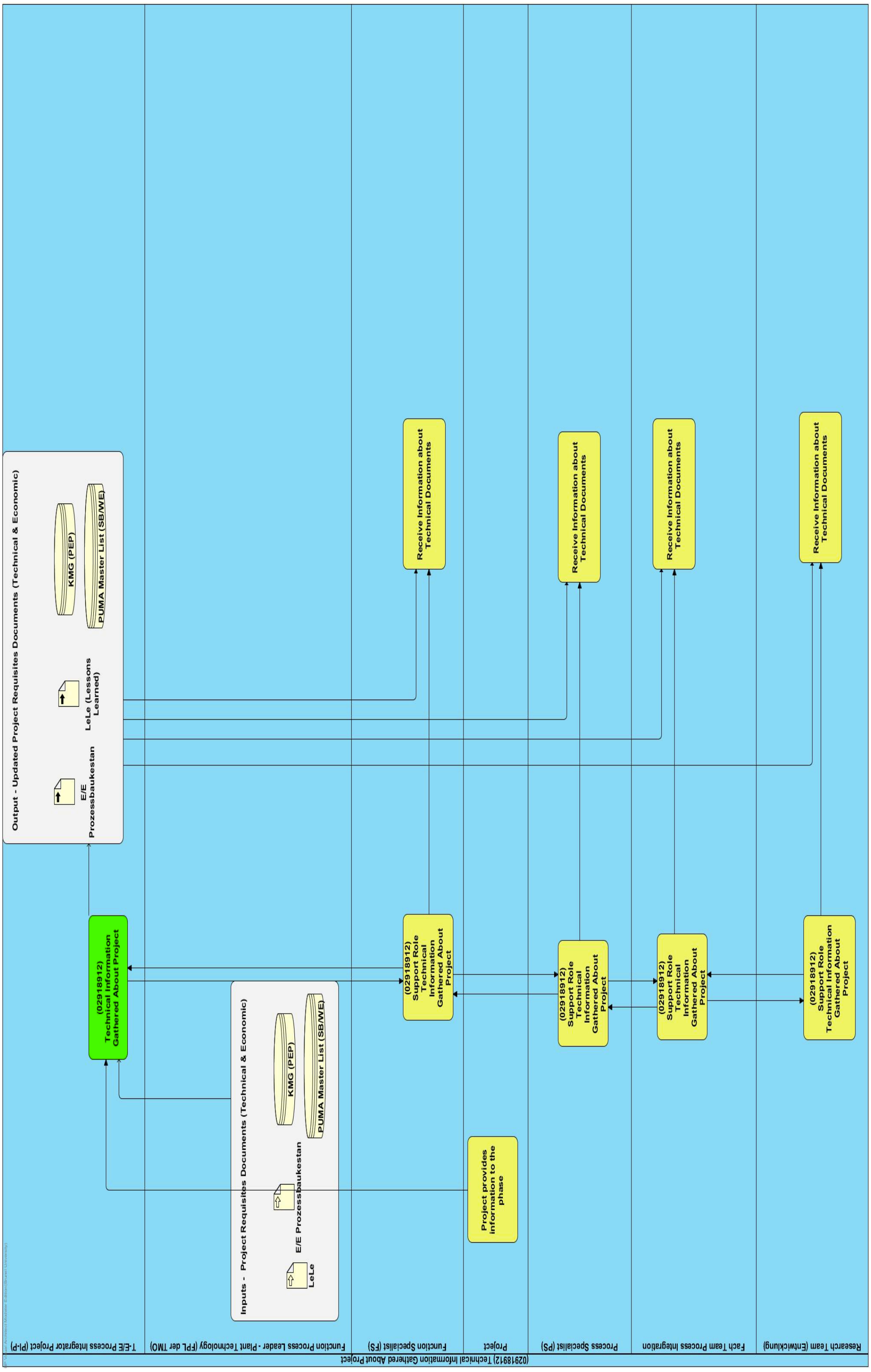

Visual Architect Modeler Edition(Brunel University)

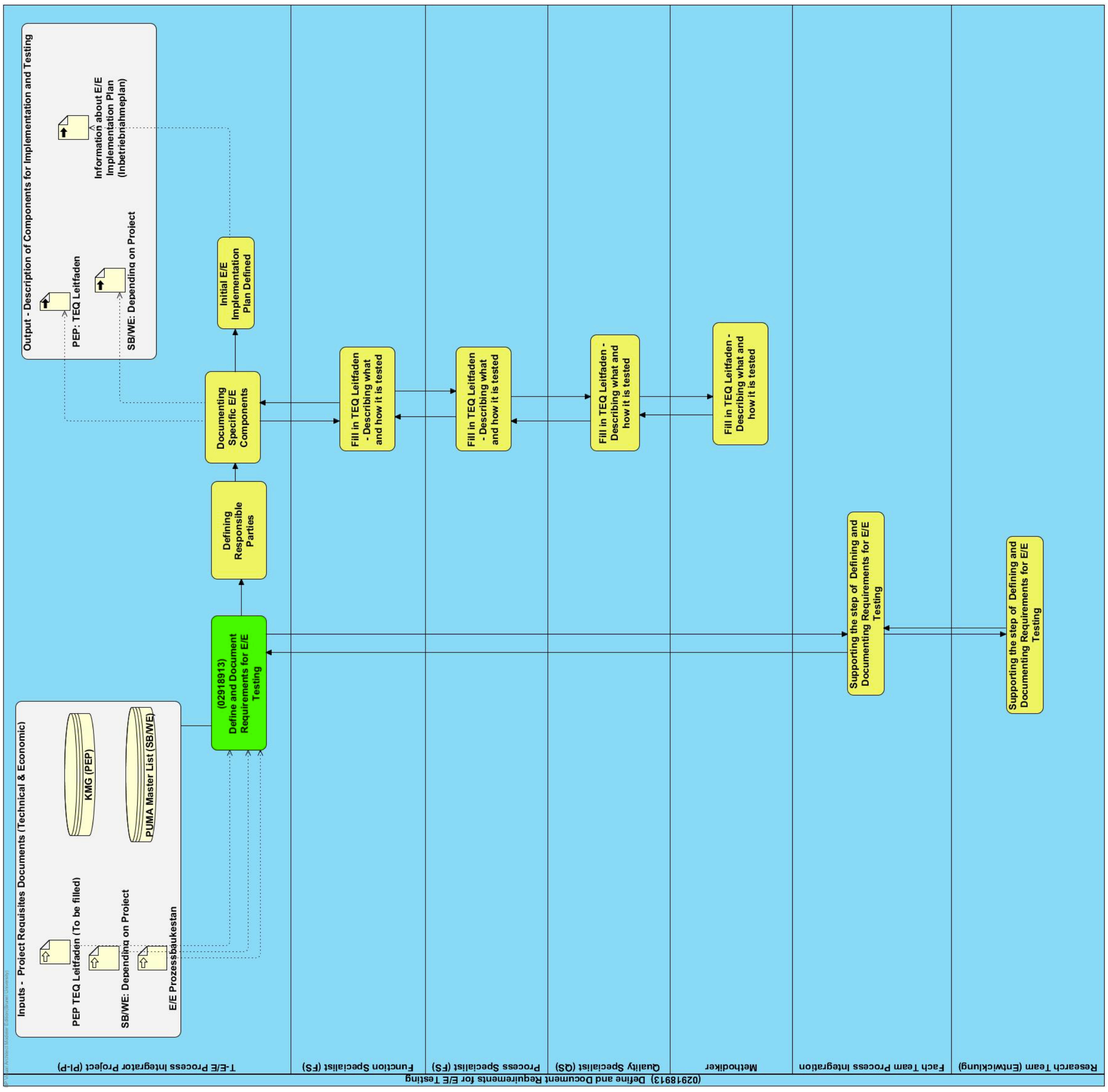


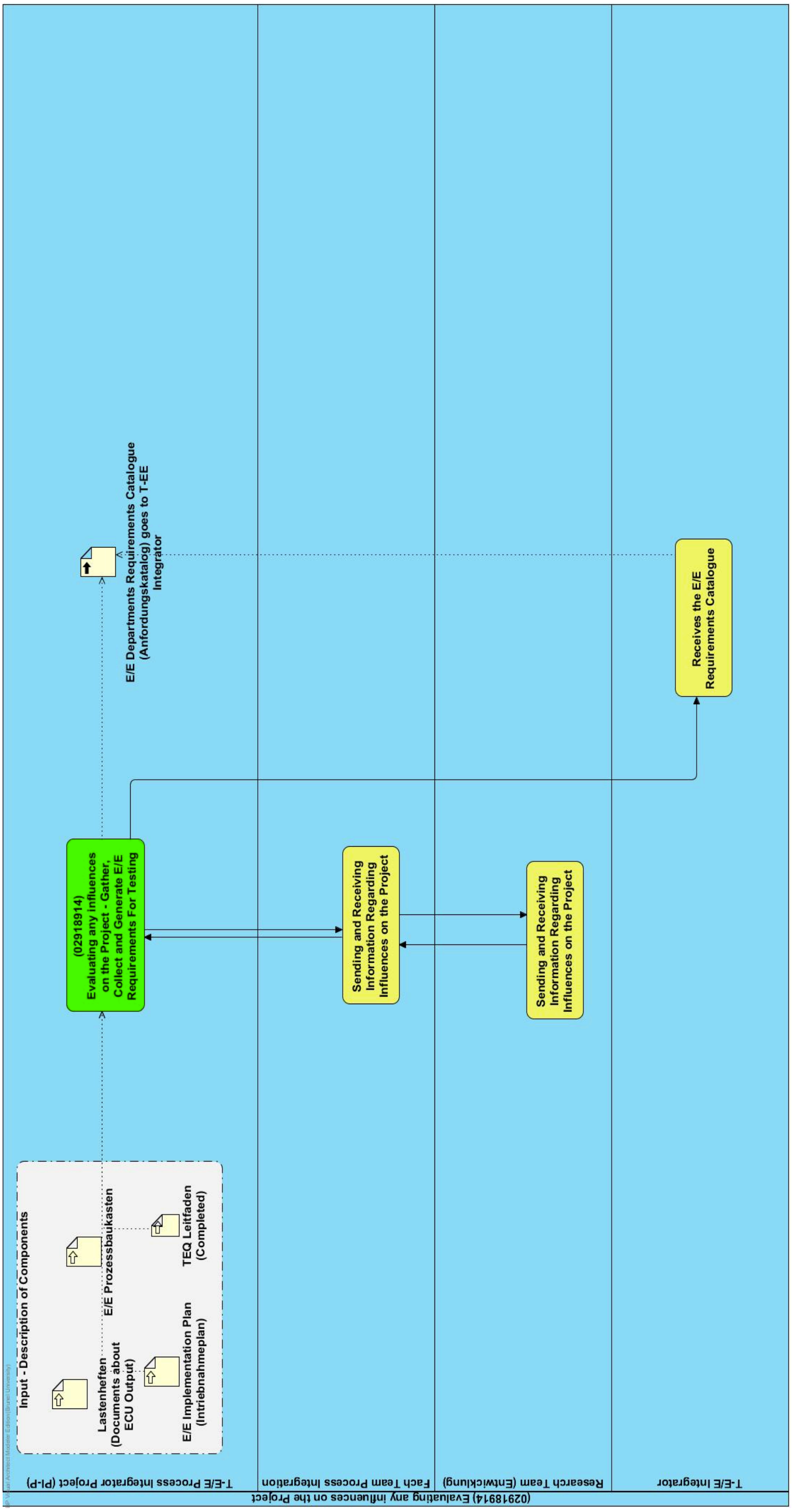
Plan and Validate EE Production Process
Arbeitkreis AK
Project/Plant Process Integrator
Project Process Specialist
Project Function Specialist
Initiating New Vehicle Project
(02918910) Appoint T-E/E Process Integrator(s)
(02918911) Project Kick Off
(02918912) Technical Information Gathered About Project
(02918913) Define and Document Requirements for E/E Testing
(02918914) Evaluating any influences on the Project
(02918915) Conduct Economical Project Evaluation (BUZ FACTOR)
(02918916) Set up E/E Implementation Plan Schedule and make plausible for Plants
(02918917) Set up/Adapt Test Content and make plausible for Plants
(02918918) Set up Testing Sequence and TVGs and adapt E/E Software/Equipment and make plausible for Plants
(02918919 1-2) Initial Validation of Test Steps and TVGs
(02918920) Create E/E Test Content and make plausible for affected Plants
(02918921) Validation of Implementation Plan (Test Content, Equipment, Core Processes & E/E Software) at Test Plant
(02918922) Conduct Initial Handover between FIZ and Plants
(02918923) Integrate E/E Implementation Plan into all Plants
(02918924) Validate of the course of E/E Implementation Plan into all Plants
(02918925) Analysis of Local Plant Problems, Documentation & Controlling
(02918926) Conduct Cross Plant Synchronization and Overall Problem Solving
(02918927) Handover Final Plans to Assembly
(02918928) Conduct Lessons Learned (LeLe)
Project Planning End

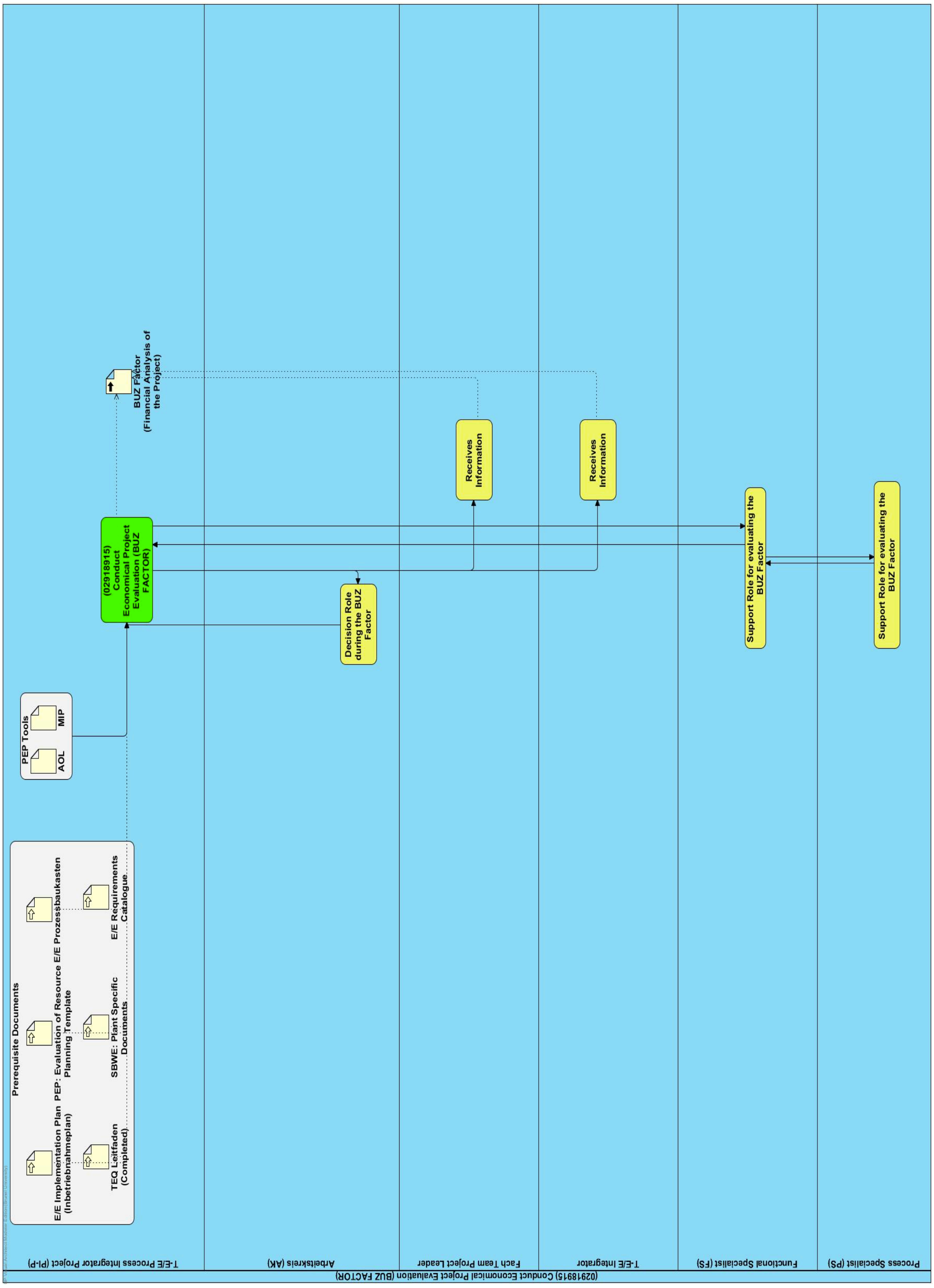

(02918910) Appoint T-E/E Process Integrator(s)
Arbeitskreis AK
Project Start Letter
(02918910) Appoint T-E/E Process Integrator(s)
T-E/E Project Process Integrator Appointed

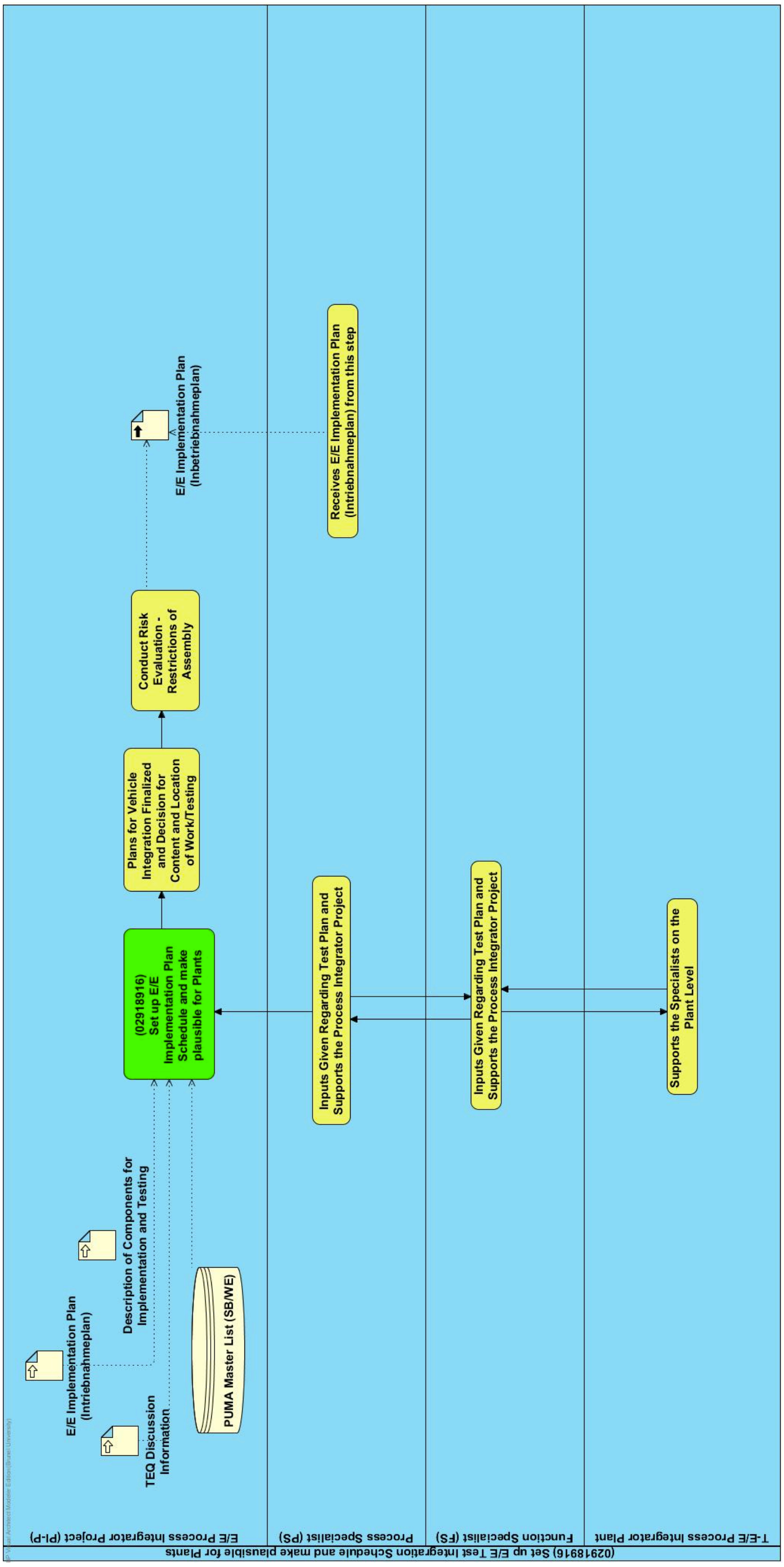

(02918911) Project Kick Off
Arbeitkreis (AK)
Project
Function Process Leader - Plant Technology (FPL der TMO)
T-E/E Process Integrator Project (PI-P)
Fach Team (FT) Process Integration
Process Specialists (PS)
Function Specialists (FS)
Process Integrator Appointed
Project Provides Input to the Step
Project Premise Available
(02918911) Project Kick Off
Set up Project Schedule
Schedule (Milestones/Phase Planning and Level of Maturity)
Set Project Team
List of Project Team (e.g. Process Integrator Plant, Process Specialists, Function Specialists, Process Integrator Plant)
Send Output Information to Project Team and concerned Stakeholders
Receives Information About the Project Team and Schedule
Receives Information About the Project Team and Schedule
Receives Information About the Project Team and Schedule
Receives Information About the Project Team and Schedule
Receives Information About the Project Team and Schedule

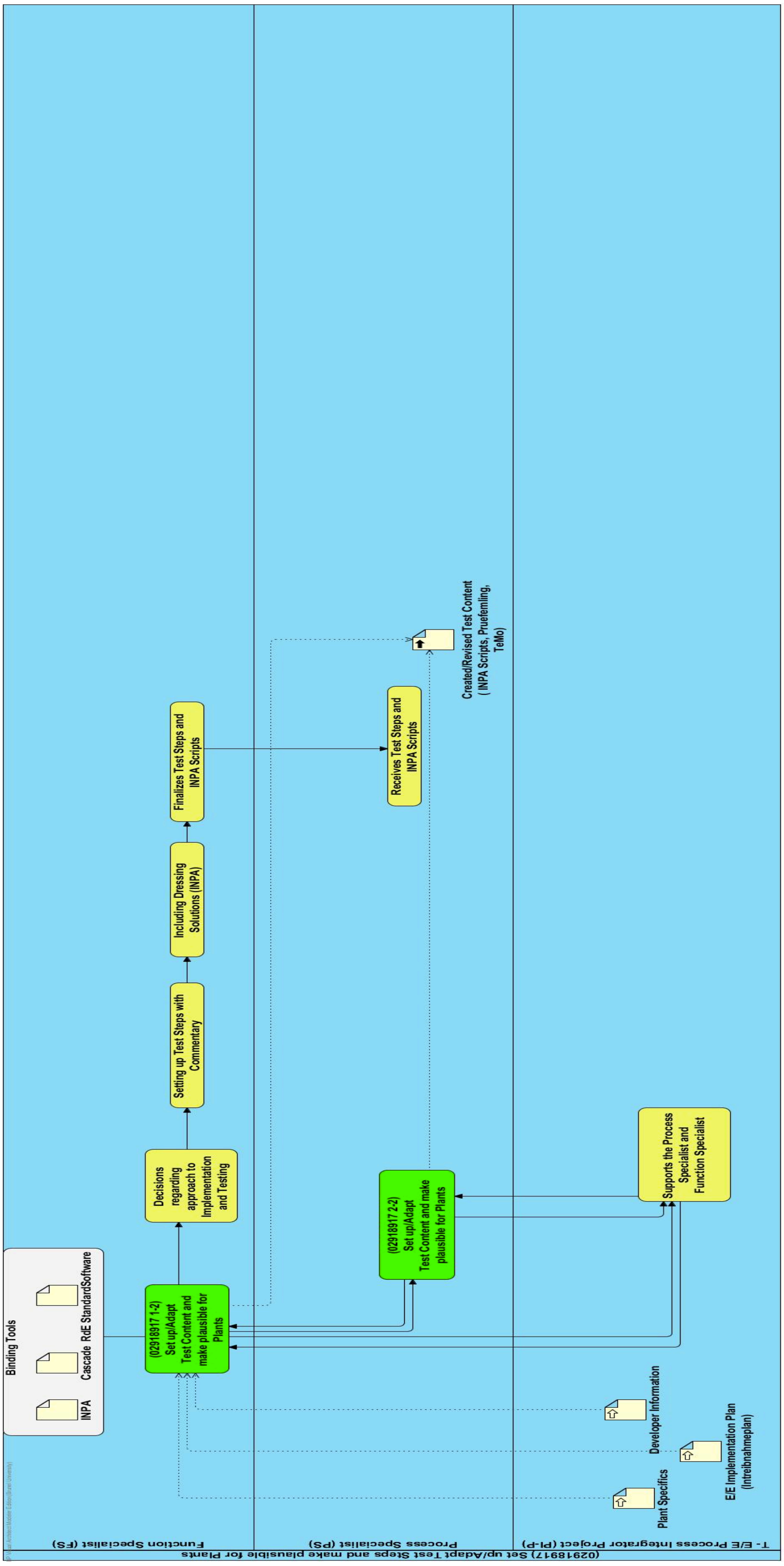

(02918912) Technical Information Gathered About Project
T-E/E Process Integrator Project (PI-P)
Function Process Leader - Plant Technology (FPL der TMO)
Function Specialist (FS)
Project
Process Specialist (PS)
Fach Team Process Integration
Research Team (Entwicklung)
Output - Updated Project Requisites Documents (Technical & Economic)
E/E Prozessbaukestan
LeLe (Lessons Learned)
KMG (PEP)
PUMA Master List (SB/WE)
Receive Information about Technical Documents
Receive Information about Technical Documents
Receive Information about Technical Documents
Receive Information about Technical Documents
(02918912) Technical Information Gathered About Project
Inputs - Project Requisites Documents (Technical & Economic)
KMG (PEP)
PUMA Master List (SB/WE)
E/E Prozessbaukestan
LeLe
(02918912) Support Role Technical Information Gathered About Project
(02918912) Support Role Technical Information Gathered About Project
(02918912) Support Role Technical Information Gathered About Project
(02918912) Support Role Technical Information Gathered About Project
Project provides information to the phase

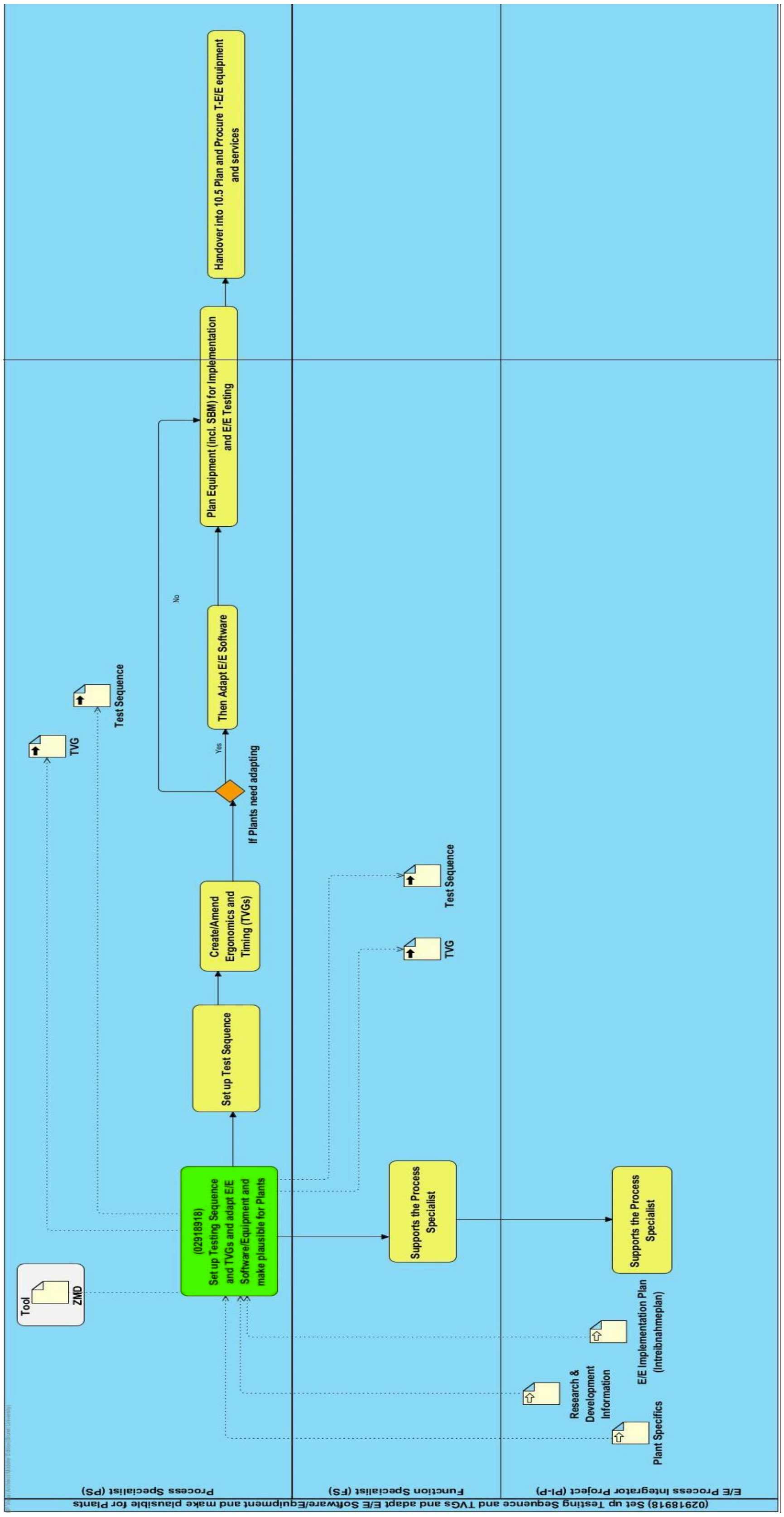

(02918913) Define and Document Requirements for E/E Testing
T-E/E Process Integrator Project (PI-P)
Function Specialist (FS)
Process Specialist (FS)
Quality Specialist (QS)
Methodiker
Fach Team Process Integration
Research Team (Entwicklung)
Inputs - Project Requisites Documents (Technical & Economic)
PEP TEQ Leitfaden (To be filled)
SB/WE: Depending on Project
E/E Prozessbaukestan
KMG (PEP)
PUMA Master List (SB/WE)
(02918913) Define and Document Requirements for E/E Testing
Defining Responsible Parties
Documenting Specific E/E Components
Initial E/E Implementation Plan Defined
Output - Description of Components for Implementation and Testing
PEP: TEQ Leitfaden
SB/WE: Depending on Project
Information about E/E Implementation Plan (Inbetriebnahmeplan)
Fill in TEQ Leitfaden - Describing what and how it is tested
Fill in TEQ Leitfaden - Describing what and how it is tested
Fill in TEQ Leitfaden - Describing what and how it is tested
Fill in TEQ Leitfaden - Describing what and how it is tested
Supporting the step of Defining and Documenting Requirements for E/E Testing
Supporting the step of Defining and Documenting Requirements for E/E Testing


(02918914) Evaluating any influences on the Project
T-E/E Process Integrator Project (PI-P)
Fach Team Process Integration
Research Team (Entwicklung)
T-E/E Integrator
Input - Description of Components
Lastenheften (Documents about ECU Output)
E/E Prozessbaukasten
TEQ Leitfaden (Completed)
E/E Implementation Plan (Intriebnahmeplan)
(02918914) Evaluating any influences on the Project - Gather, Collect and Generate E/E Requirements For Testing
Sending and Receiving Information Regarding Influences on the Project
Sending and Receiving Information Regarding Influences on the Project
E/E Departments Requirements Catalogue (Anfordungskatalog) goes to T-EE Integrator
Receives the E/E Requirements Catalogue

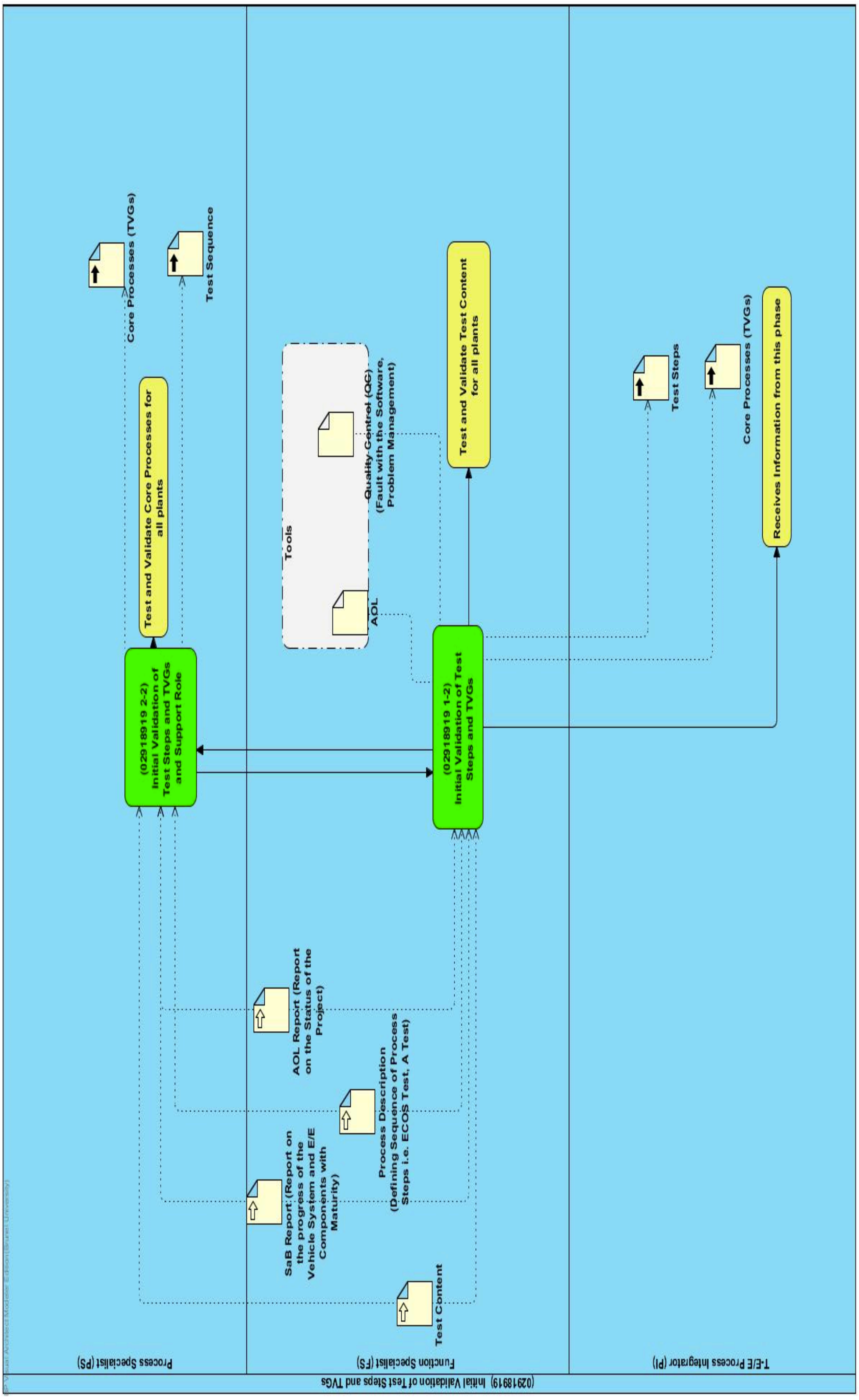

(02918915) Conduct Economical Project Evaluation (BUZ FACTOR)
T-E/E Process Integrator Project (PI-P)
Arbeitskreis (AK)
Fach Team Project Leader
T-E/E Integrator
Functional Specialist (FS)
Process Specialist (PS)
Prerequisite Documents
E/E Implementation Plan (Inbetriebnahmeplan)
PEP: Evaluation of Resource Planning Template
E/E Prozessbaukasten
TEQ Leitfaden (Completed)
SBWE: Plant Specific Documents
E/E Requirements Catalogue
PEP Tools
AOL
MIP
(02918915) Conduct Economical Project Evaluation (BUZ FACTOR)
BUZ Factor (Financial Analysis of the Project)
Decision Role during the BUZ Factor
Receives Information
Receives Information
Support Role for evaluating the BUZ Factor
Support Role for evaluating the BUZ Factor


(02918916) Set up E/E Test Integration Schedule and make plausible for Plants
E/E Process Integrator Project (PI-P)
Process Specialist (PS)
Function Specialist (FS)
T-E/E Process Integrator Plant
E/E Implementation Plan (Intriebnahmeplan)
TEQ Discussion Information
Description of Components for Implementation and Testing
PUMA Master List (SB/WE)
(02918916) Set up E/E Implementation Plan Schedule and make plausible for Plants
Plans for Vehicle Integration Finalized and Decision for Content and Location of Work/Testing
Conduct Risk Evaluation - Restrictions of Assembly
E/E Implementation Plan (Inbetriebnahmeplan)
Receives E/E Implementation Plan (Intriebnahmeplan) from this step
Inputs Given Regarding Test Plan and Supports the Process Integrator Project
Inputs Given Regarding Test Plan and Supports the Process Integrator Project
Supports the Specialists on the Plant Level

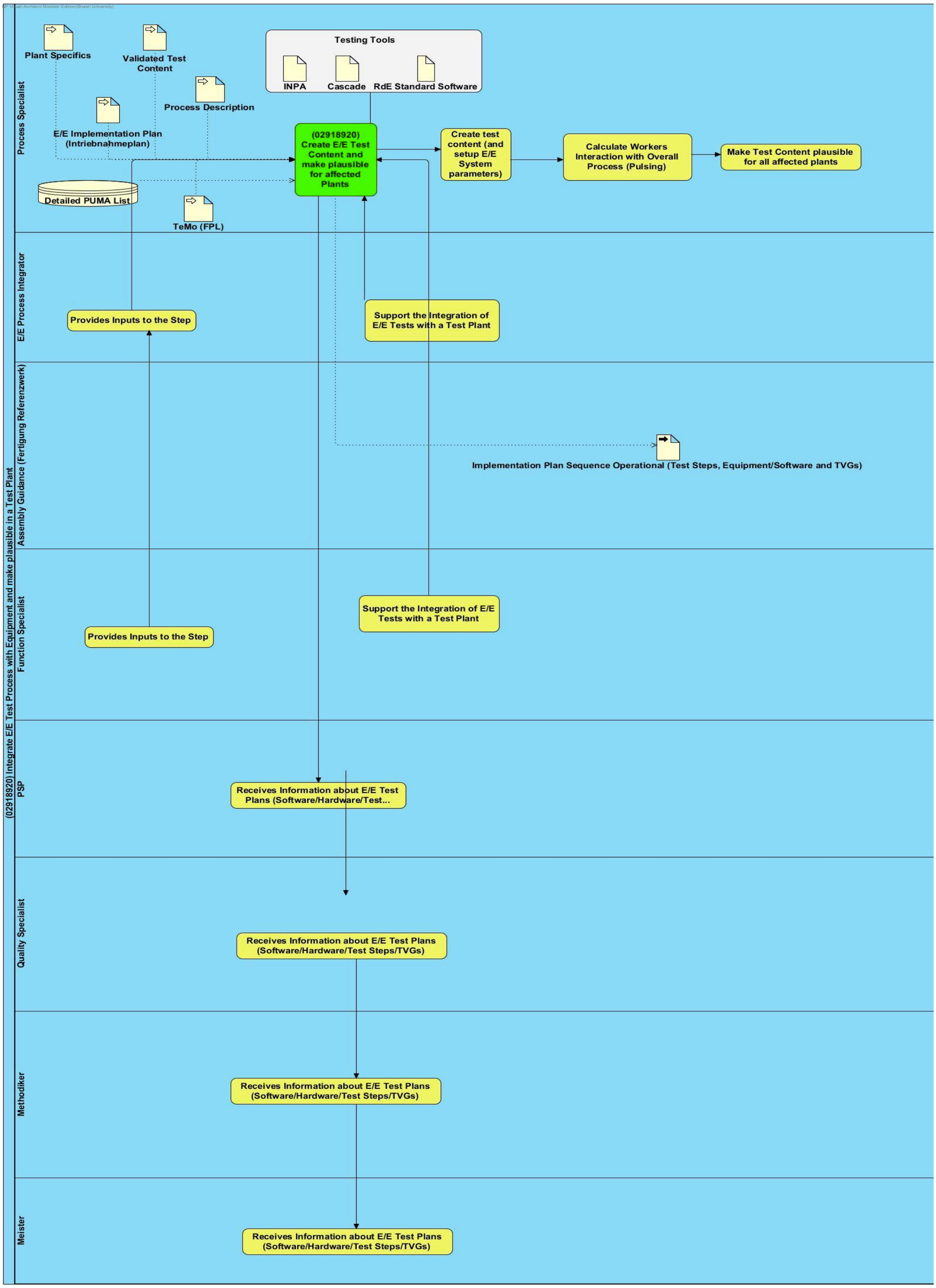

(02918917) Set up/Adapt Test Steps and make plausible for Plants
Function Specialist (FS)
Process Specialist (PS)
T - E/E Process Integrator Project (PI-P)
Binding Tools
INPA
Cascade
RdE StandardSoftware
(02918917 1-2) Set up/Adapt Test Content and make plausible for Plants
Decisions regarding approach to Implementation and Testing
Setting up Test Steps with Commentary
Including Dressing Solutions (INPA)
Finalizes Test Steps and INPA Scripts
Receives Test Steps and INPA Scripts
Created/Revised Test Content (INPA Scripts, Pruefenling, TeMo)
(02918917 2-2) Set up/Adapt Test Content and make plausible for Plants
Supports the Process Specialist and Function Specialist
Developer Information
E/E Implementation Plan (Intreibnahmeplan)
Plant Specifics

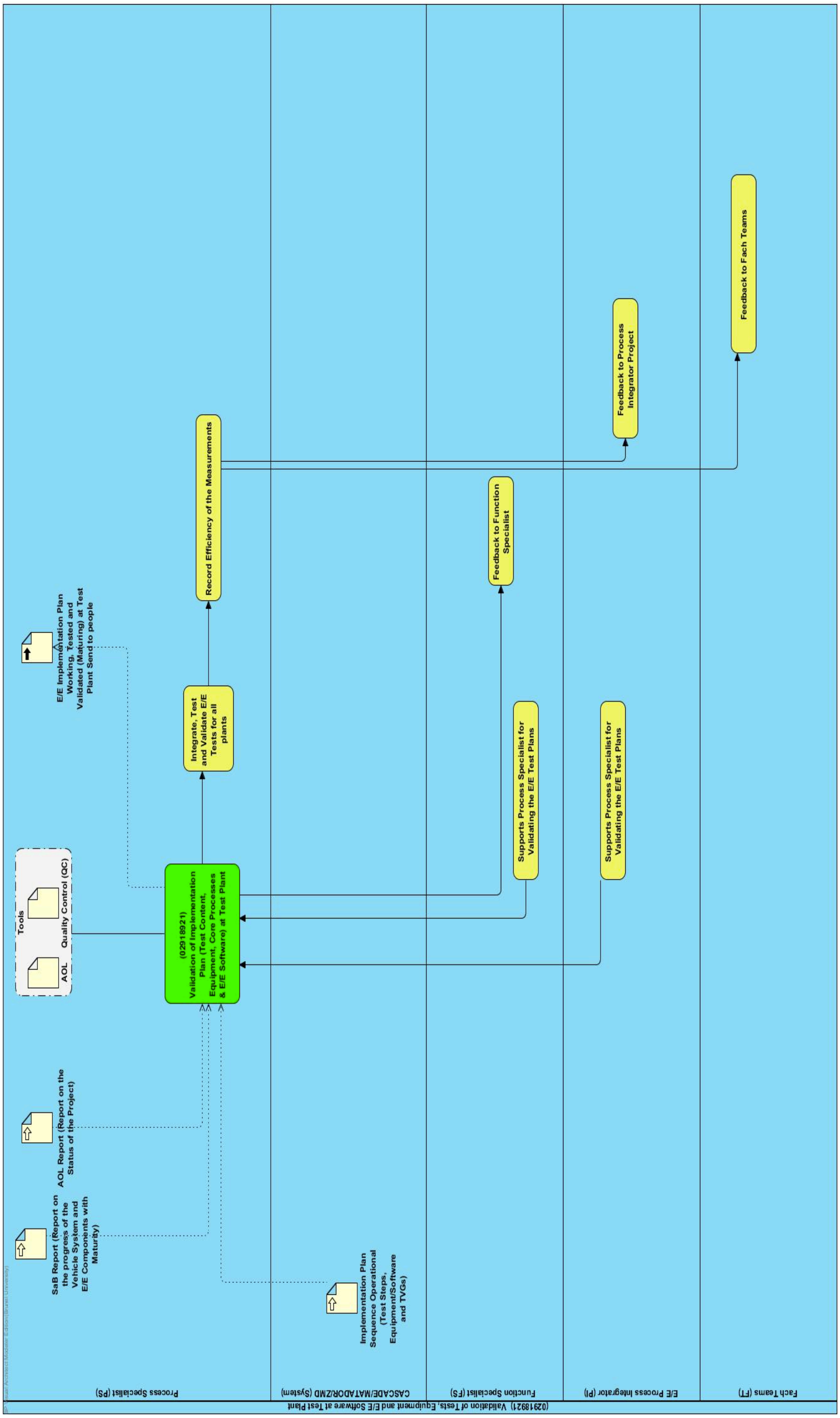


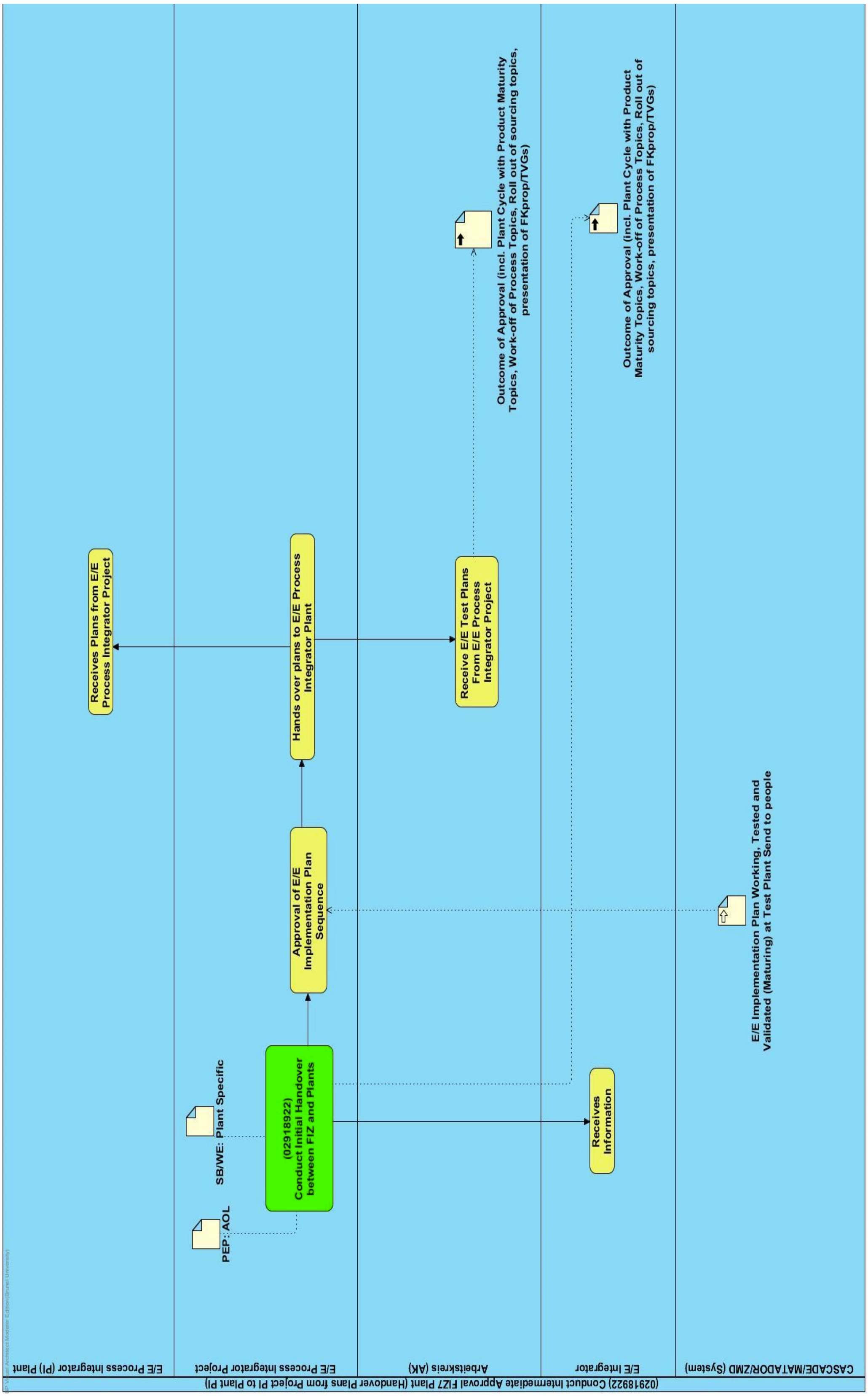
(02918918) Set up Testing Sequence and TVGs and adapt E/E Software/Equipment and make plausible for Plants
Process Specialist (PS)
Function Specialist (FS)
E/E Process Integrator Project (PI-P)
Tool
ZMD
(02918918) Set up Testing Sequence and TVGs and adapt E/E Software/Equipment and make plausible for Plants
Set up Test Sequence
Create/Amend Ergonomics and Timing (TVGs)
If Plants need adapting
Yes
No
Then Adapt E/E Software
Plan Equipment (incl. SBM) for Implementation and E/E Testing
Handover into 10.5 Plan and Procure T-E/E equipment and services
TVG
Test Sequence
TVG
Test Sequence
Supports the Process Specialist
Supports the Process Specialist
Plant Specifics
Research & Development Information
E/E Implementation Plan (Intreibnahmeplan)

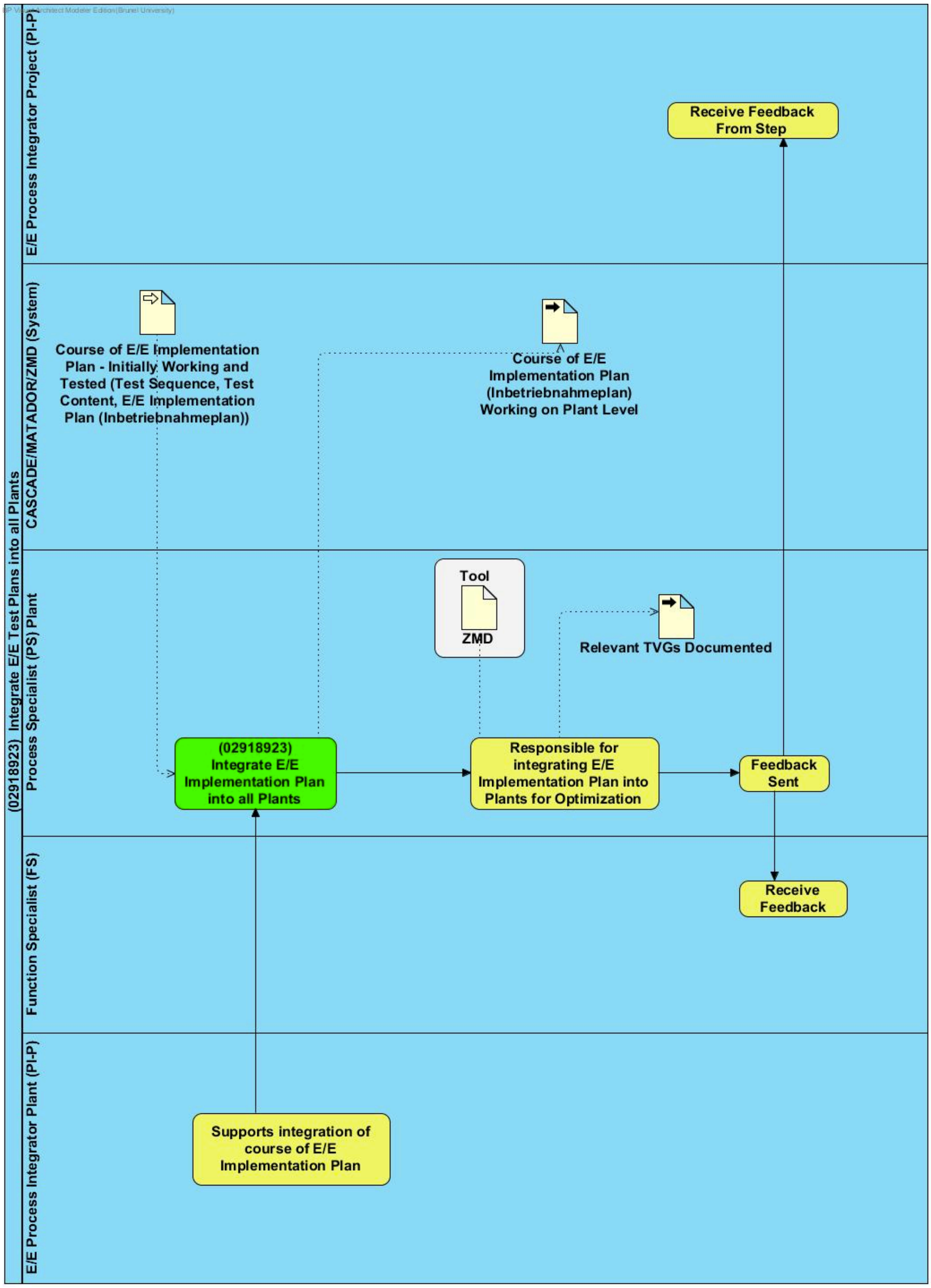


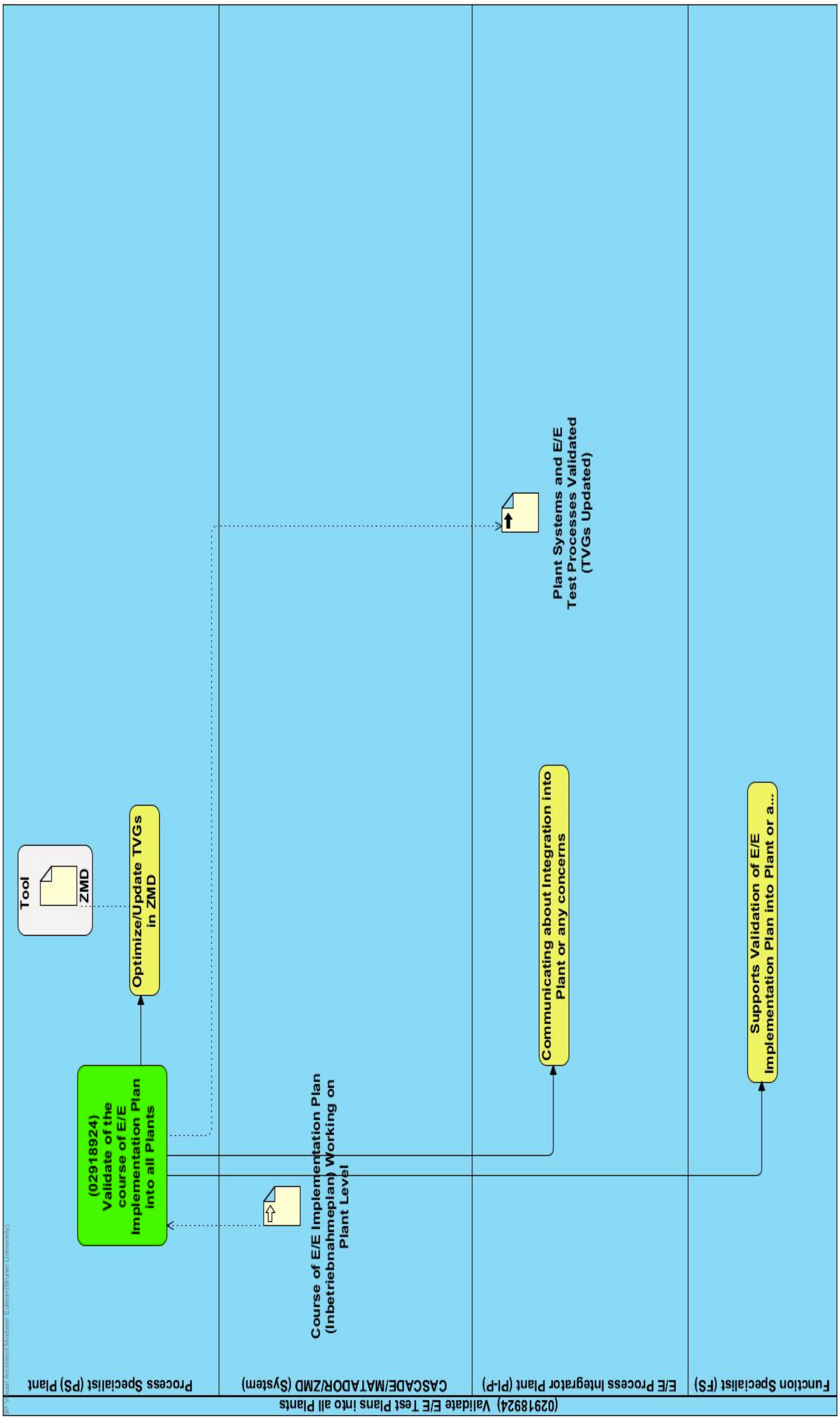
(02918919) Initial Validation of Test Steps and TVGs
Process Specialist (PS)
Function Specialist (FS)
T-E/E Process Integrator (PI)
Core Processes (TVGs)
Test Sequence
Test and Validate Core Processes for all plants
(02918919 2-2) Initial Validation of Test Steps and TVGs and Support Role
Tools
Quality Control (QC) (Fault with the Software, Problem Management)
AOL
Test and Validate Test Content for all plants
(02918919 1-2) Initial Validation of Test Steps and TVGs
Test Steps
Core Processes (TVGs)
Receives Information from this phase
AOL Report (Report on the Status of the Project)
Process Description (Defining Sequence of Process Steps i.e. ECOS Test, A Test)
SaB Report (Report on the progress of the Vehicle System and E/E Components with Maturity)
Test Content

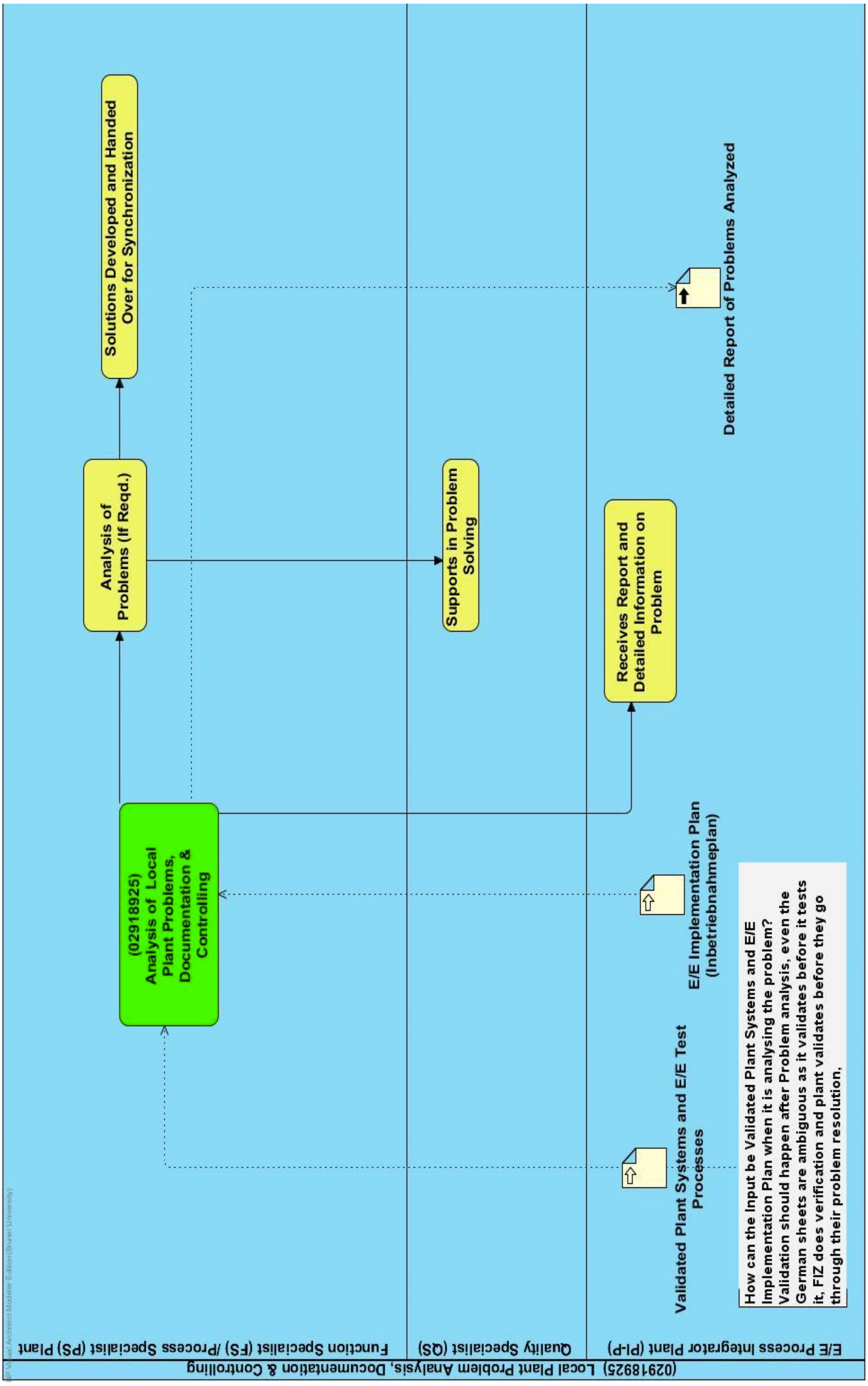

(02918920) Integrate E/E Test Process with Equipment and make plausible in a Test Plant
Process Specialist
E/E Process Integrator
Assembly Guidance (Fertigung Referenzwerk)
Function Specialist
PSP
Quality Specialist
Methodiker
Meister
Plant Specifics
Validated Test Content
Process Description
E/E Implementation Plan (Intriebnahmeplan)
Detailed PUMA List
TeMo (FPL)
Testing Tools
INPA
Cascade
RdE Standard Software
(02918920) Create E/E Test Content and make plausible for affected Plants
Create test content (and setup E/E System parameters)
Calculate Workers Interaction with Overall Process (Pulsing)
Make Test Content plausible for all affected plants
Provides Inputs to the Step
Support the Integration of E/E Tests with a Test Plant
Implementation Plan Sequence Operational (Test Steps, Equipment/Software and TVGs)
Support the Integration of E/E Tests with a Test Plant
Provides Inputs to the Step
Receives Information about E/E Test Plans (Software/Hardware/Test...
Receives Information about E/E Test Plans (Software/Hardware/Test Steps/TVGs)
Receives Information about E/E Test Plans (Software/Hardware/Test Steps/TVGs)
Receives Information about E/E Test Plans (Software/Hardware/Test Steps/TVGs)

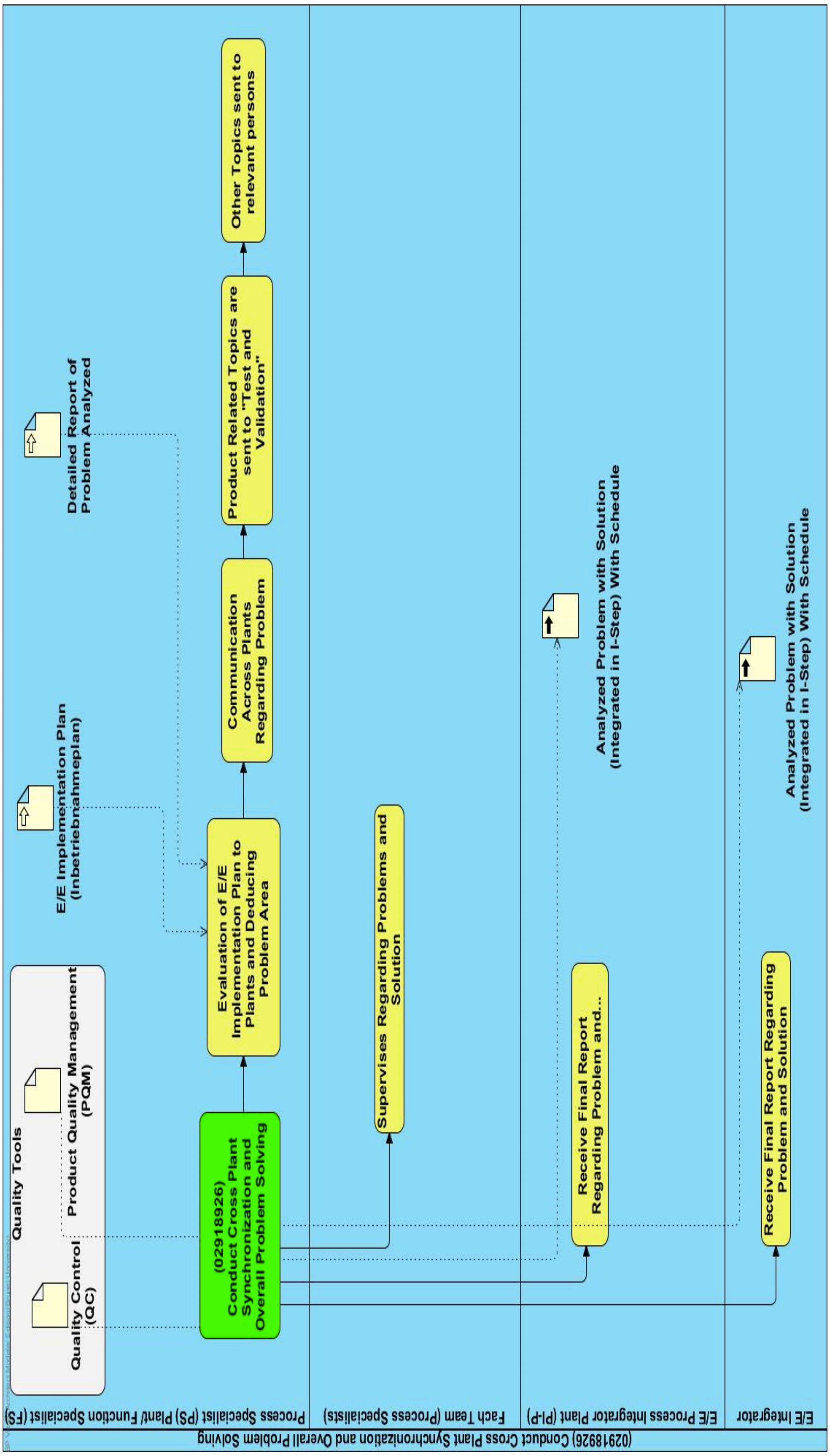

(02918921) Validation of Tests, Equipment and E/E Software at Test Plant
Process Specialist (PS)
CASCADE/MATADOR/ZMD (System)
Function Specialist (FS)
E/E Process Integrator (PI)
Fach Teams (FT)
SaB Report (Report on the progress of the Vehicle System and E/E Components with Maturity)
AOL Report (Report on the Status of the Project)
Tools
AOL
Quality Control (QC)
E/E Implementation Plan Working, Tested and Validated (Maturing) at Test Plant Send to people
Implementation Plan Sequence Operational (Test Steps, Equipment/Software and TVGs)
(02918921) Validation of Implementation Plan (Test Content, Equipment, Core Processes & E/E Software) at Test Plant
Integrate, Test and Validate E/E Tests for all plants
Record Efficiency of the Measurements
Feedback to Function Specialist
Supports Process Specialist for Validating the E/E Test Plans
Supports Process Specialist for Validating the E/E Test Plans
Feedback to Process Integrator Project
Feedback to Fach Teams


(02918922) Conduct Intermediate Approval FIZ7 Plant (Handover Plans from Project PI to Plant PI)
E/E Process Integrator (PI) Plant
E/E Process Integrator Project
Arbeitskreis (AK)
E/E Integrator
CASCADE/MATADOR/ZMD (System)
PEP: AOL
SB/WE: Plant Specific
(02918922) Conduct Initial Handover between FIZ and Plants
Approval of E/E Implementation Plan Sequence
Hands over plans to E/E Process Integrator Plant
Receives Plans from E/E Process Integrator Project
Receive E/E Test Plans From E/E Process Integrator Project
Receives Information
Outcome of Approval (incl. Plant Cycle with Product Maturity Topics, Work-off of Process Topics, Roll out of sourcing topics, presentation of FKprop/TVGs)
Outcome of Approval (incl. Plant Cycle with Product Maturity Topics, Work-off of Process Topics, Roll out of sourcing topics, presentation of FKprop/TVGs)
E/E Implementation Plan Working, Tested and Validated (Maturing) at Test Plant Send to people

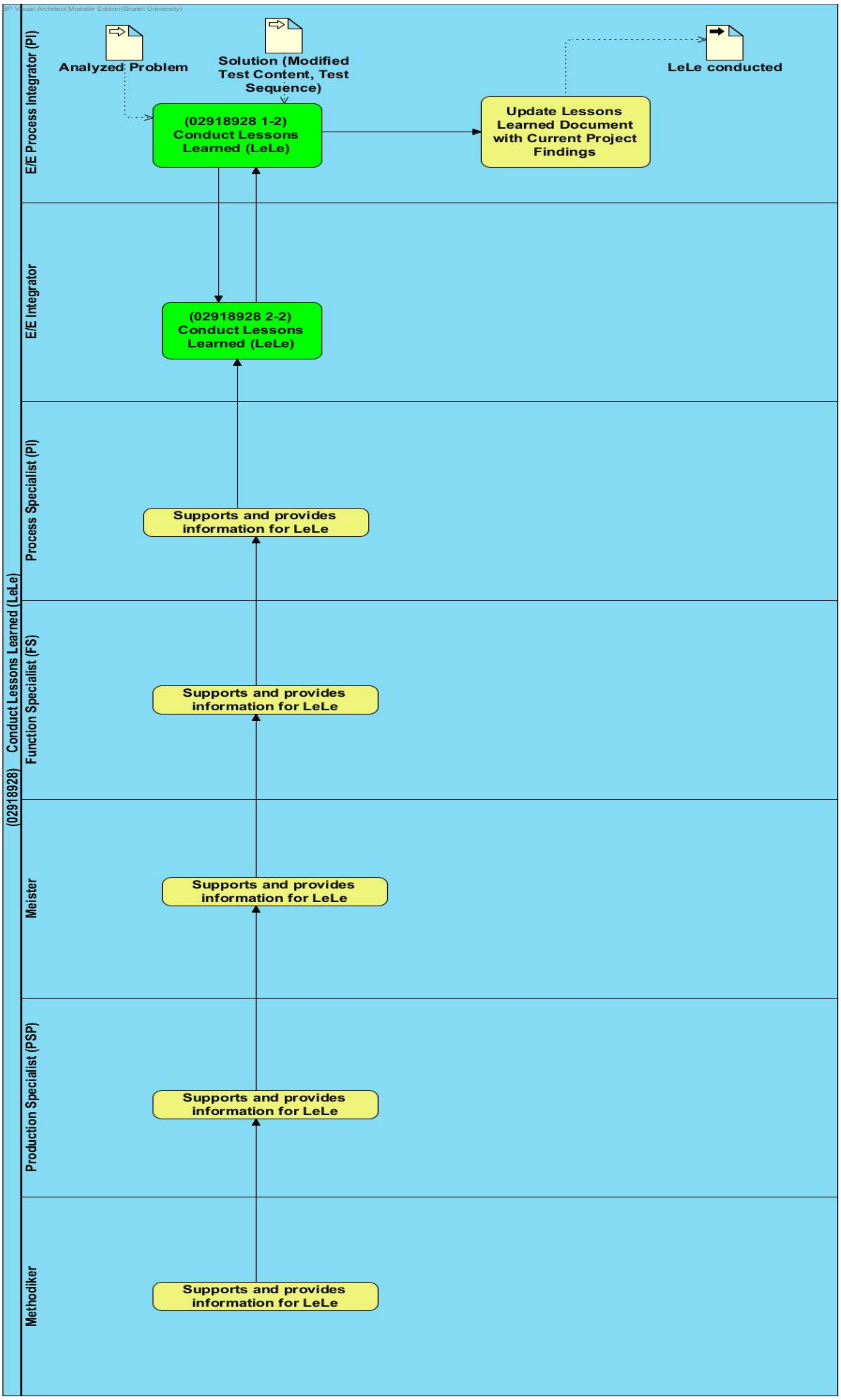

(02918923) Integrate E/E Test Plans into all Plants
E/E Process Integrator Project (PI-P)
CASCADE/MATADOR/ZMD (System)
Process Specialist (PS) Plant
Function Specialist (FS)
E/E Process Integrator Plant (PI-P)
Receive Feedback From Step
Course of E/E Implementation Plan - Initially Working and Tested (Test Sequence, Test Content, E/E Implementation Plan (Inbetriebnahmeplan))
Course of E/E Implementation Plan (Inbetriebnahmeplan) Working on Plant Level
Tool
ZMD
Relevant TVGs Documented
(02918923) Integrate E/E Implementation Plan into all Plants
Responsible for integrating E/E Implementation Plan into Plants for Optimization
Feedback Sent
Receive Feedback
Supports integration of course of E/E Implementation Plan


(02918924) Validate E/E Test Plans into all Plants
Process Specialist (PS) Plant
CASCADE/MATADOR/ZMD (System)
E/E Process Integrator Plant (PI-P)
Function Specialist (FS)
(02918924) Validate of the course of E/E Implementation Plan into all Plants
Optimize/Update TVGs in ZMD
Tool
ZMD
Course of E/E Implementation Plan (Inbetriebnahmeplan) Working on Plant Level
Plant Systems and E/E Test Processes Validated (TVGs Updated)
Communicating about Integration into Plant or any concerns
Supports Validation of E/E Implementation Plan into Plant or a...

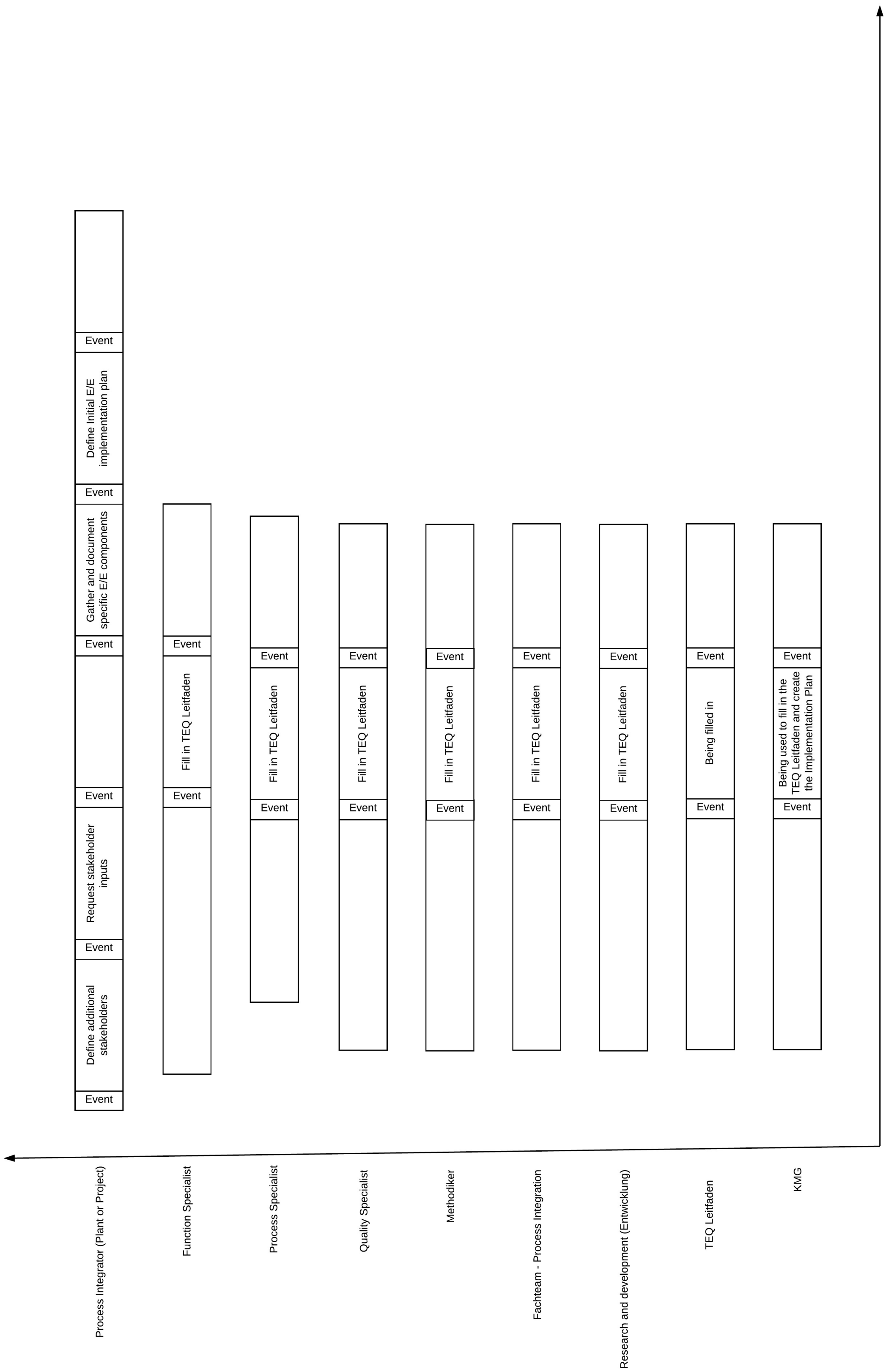

(02918925) Local Plant Problem Analysis, Documentation & Controlling
Function Specialist (FS) /Process Specialist (PS) Plant
Quality Specialist (QS)
E/E Process Integrator Plant (PI-P)
(02918925) Analysis of Local Plant Problems, Documentation & Controlling
Analysis of Problems (If Reqd.)
Solutions Developed and Handed Over for Synchronization
Supports in Problem Solving
Receives Report and Detailed Information on Problem
Detailed Report of Problems Analyzed
E/E Implementation Plan (Inbetriebnahmeplan)
Validated Plant Systems and E/E Test Processes
How can the Input be Validated Plant Systems and E/E Implementation Plan when it is analysing the problem? Validation should happen after Problem analysis, even the German sheets are ambiguous as it validates before it tests it, FIZ does verification and plant validates before they go through their problem resolution.

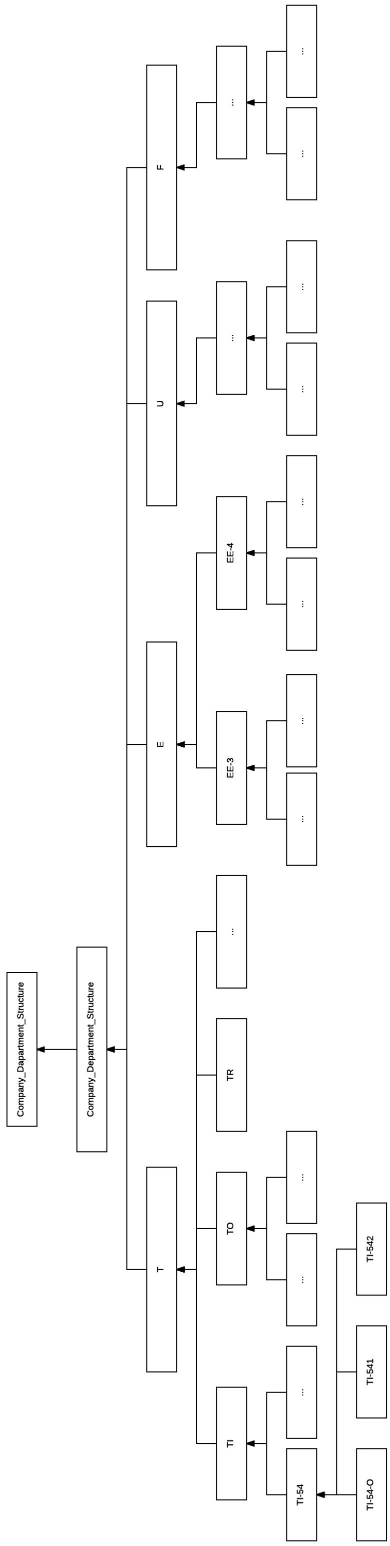

(02918926) Conduct Cross Plant Synchronization and Overall Problem Solving
Process Specialist (PS) Plant Function Specialist (FS)
Fach Team (Process Specialists)
E/E Process Integrator Plant (PI-P)
E/E Integrator
Quality Tools
Quality Control (QC)
Product Quality Management (PQM)
E/E Implementation Plan (Inbetriebnahmeplan)
Detailed Report of Problem Analyzed
(02918926) Conduct Cross Plant Synchronization and Overall Problem Solving
Evaluation of E/E Implementation Plan to Plants and Deducing Problem Area
Communication Across Plants Regarding Problem
Product Related Topics are sent to "Test and Validation"
Other Topics sent to relevant persons
Supervises Regarding Problems and Solution
Receive Final Report Regarding Problem and...
Analyzed Problem with Solution (Integrated in I-Step) With Schedule
Receive Final Report Regarding Problem and Solution
Analyzed Problem with Solution (Integrated in I-Step) With Schedule

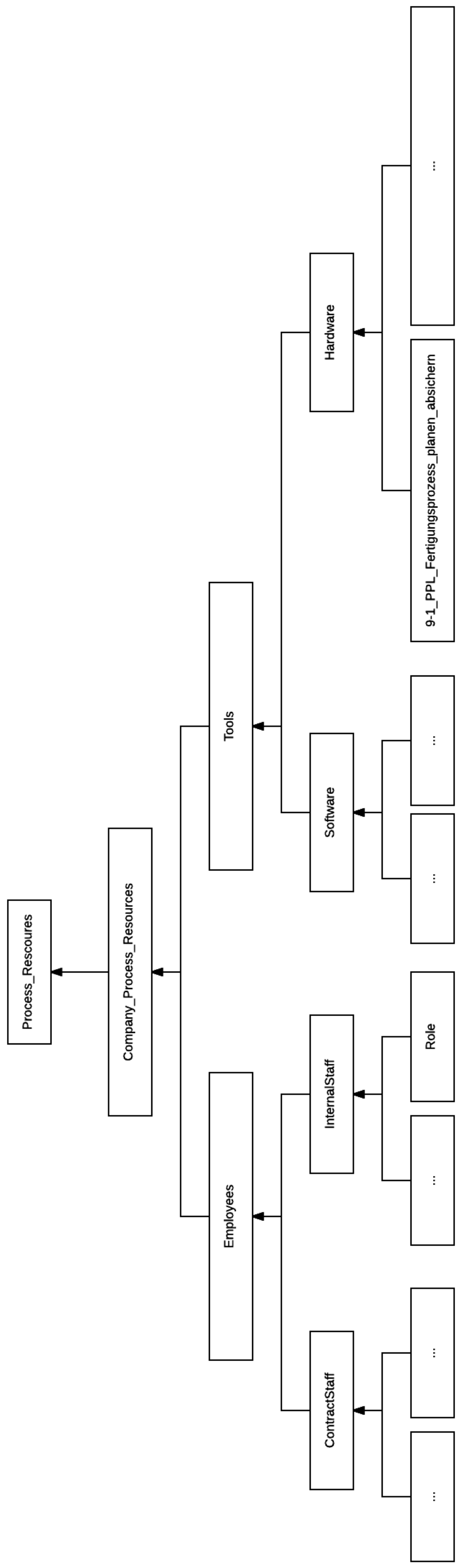

(02918927) Handover Final Plans to Assembly
Process Specialist (PS)
CASCADE/MATADOR/ZMD (System)
Arbeitskreis (AK)
Health & Safety Department
Function Specialist (FS)
E/E Process Integrator Plant
Meister
Production Specialist (PSP)
Master HN
(Template Document to
be used for HN)
(02918927)
Handover Final Plans
to Assembly
HN Contract
Produced (Stating
the Plant Assembly
is now ready for
Production)
Information Sent To
Other Stakeholders
Finalized course of E/E Implementation Plan
(Inbetriebnahmeplan)
HN
Receives Final HN
Contract
Supports Handover
of Plans to...
Supports Handover
of Plans to...
Manages &
Supports...
Receives Information Regarding
Handover of E/E Implementation...
Receives Information Regarding
Handover of E/E Implementation...

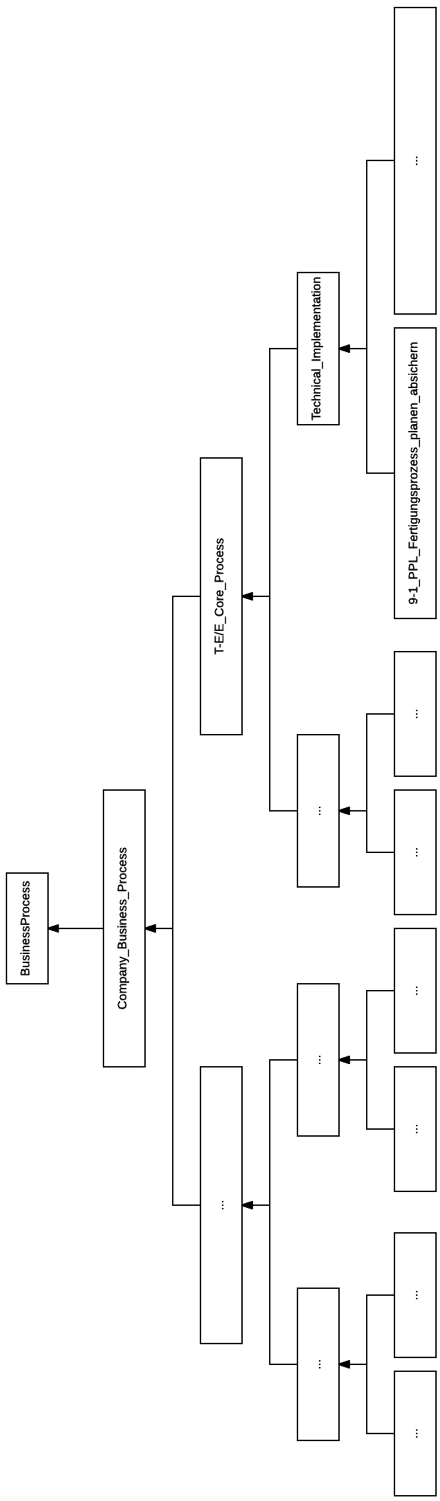

(02918928) Conduct Lessons Learned (LeLe)
E/E Process Integrator (PI)
E/E Integrator
Process Specialist (PI)
Function Specialist (FS)
Meister
Production Specialist (PSP)
Methodiker
Analyzed Problem
Solution (Modified Test Content, Test Sequence)
LeLe conducted
(02918928 1-2) Conduct Lessons Learned (LeLe)
Update Lessons Learned Document with Current Project Findings
(02918928 2-2) Conduct Lessons Learned (LeLe)
Supports and provides information for LeLe
Supports and provides information for LeLe
Supports and provides information for LeLe
Supports and provides information for LeLe
Supports and provides information for LeLe

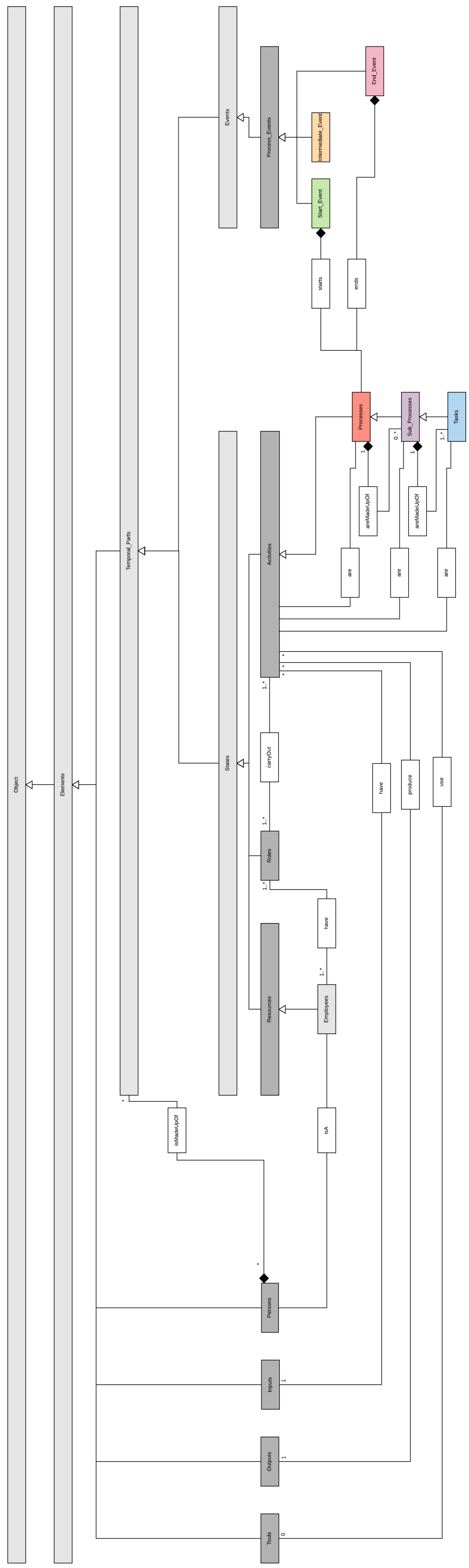
F. Ontologies Business Process Diagrams

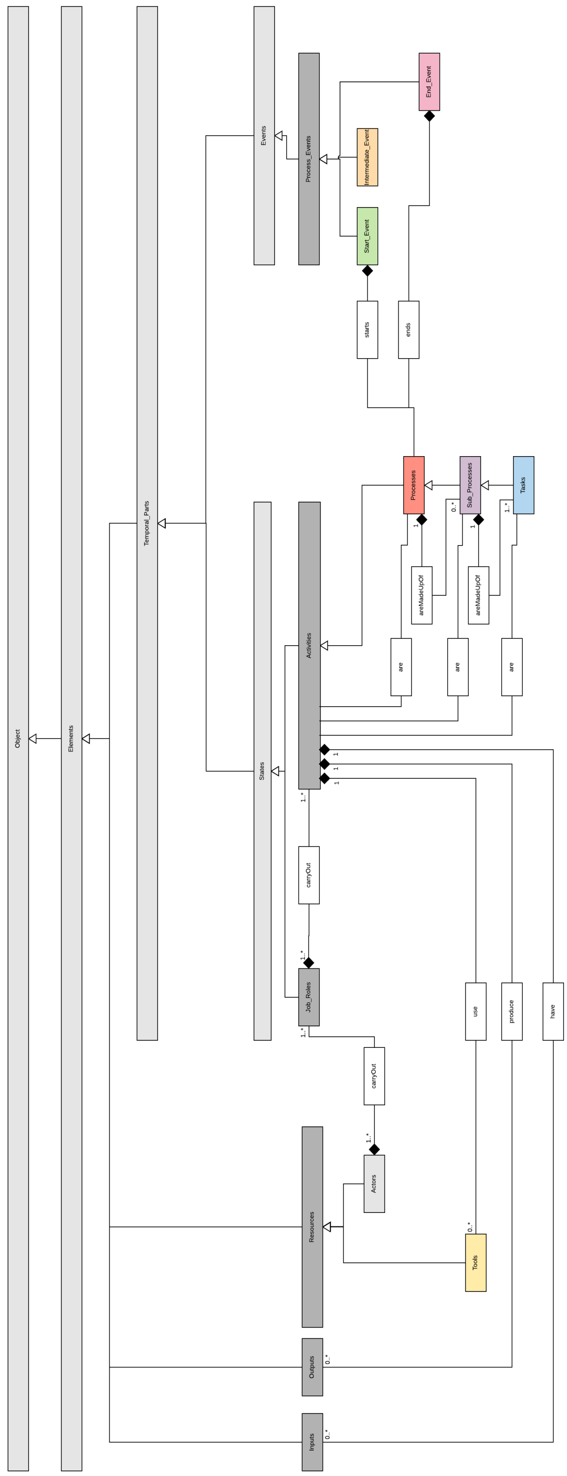

Process Integrator (Plant or Project)
Event
Define additional stakeholders
Event
Request stakeholder inputs
Event
Event
Gather and document specific E/E components
Event
Define Initial E/E implementation plan
Event
Function Specialist
Event
Fill in TEQ Leitfaden
Event
Process Specialist
Event
Fill in TEQ Leitfaden
Event
Quality Specialist
Event
Fill in TEQ Leitfaden
Event
Methodiker
Event
Fill in TEQ Leitfaden
Event
Fachteam - Process Integration
Event
Fill in TEQ Leitfaden
Event
Research and development (Entwicklung)
Event
Fill in TEQ Leitfaden
Event
TEQ Leitfaden
Event
Being filled in
Event
KMG
Event
Being used to fill in the TEQ Leitfaden and create the Implementation Plan
Event

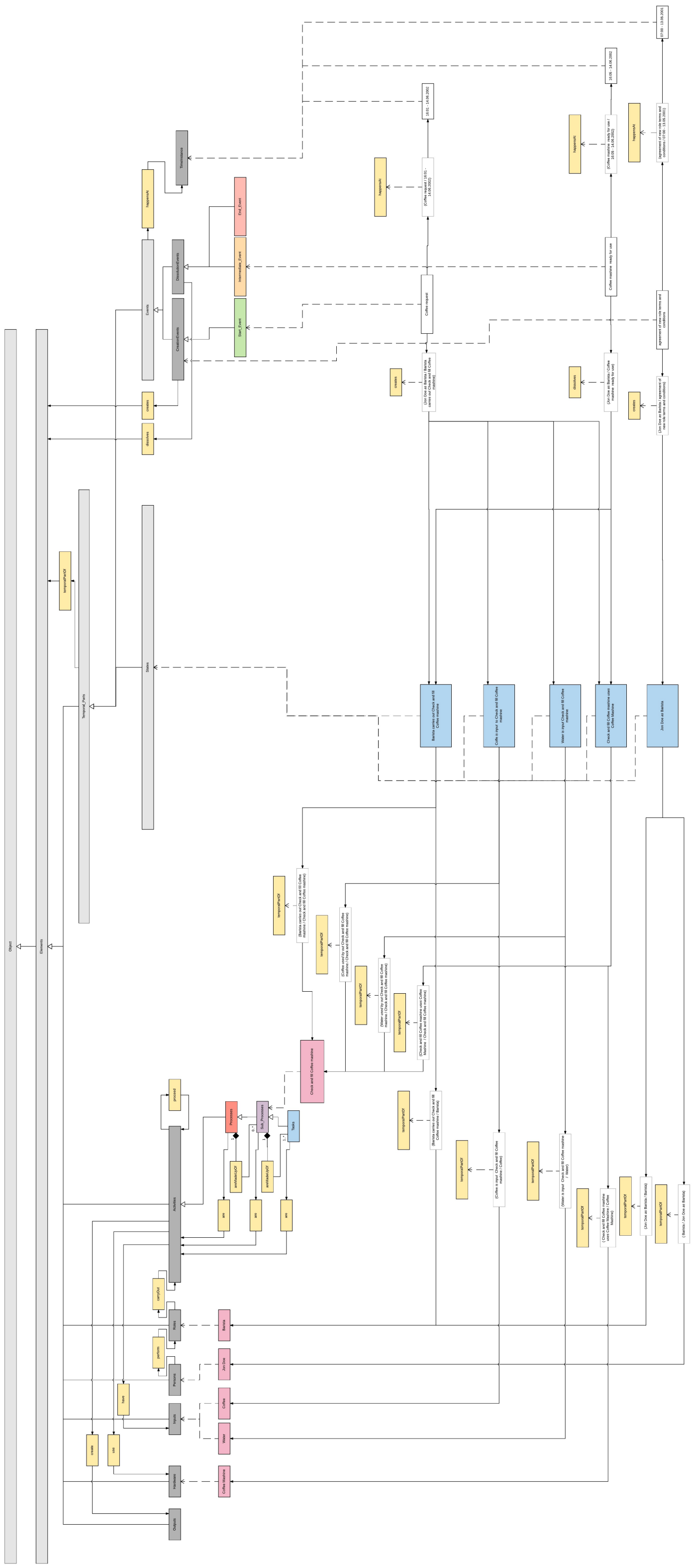

Company_Dapartment_Structure
Company_Department_Structure
T
E
U
F
TI
TO
TR
...
EE-3
EE-4
TI-54
TI-54-O
TI-541
TI-542

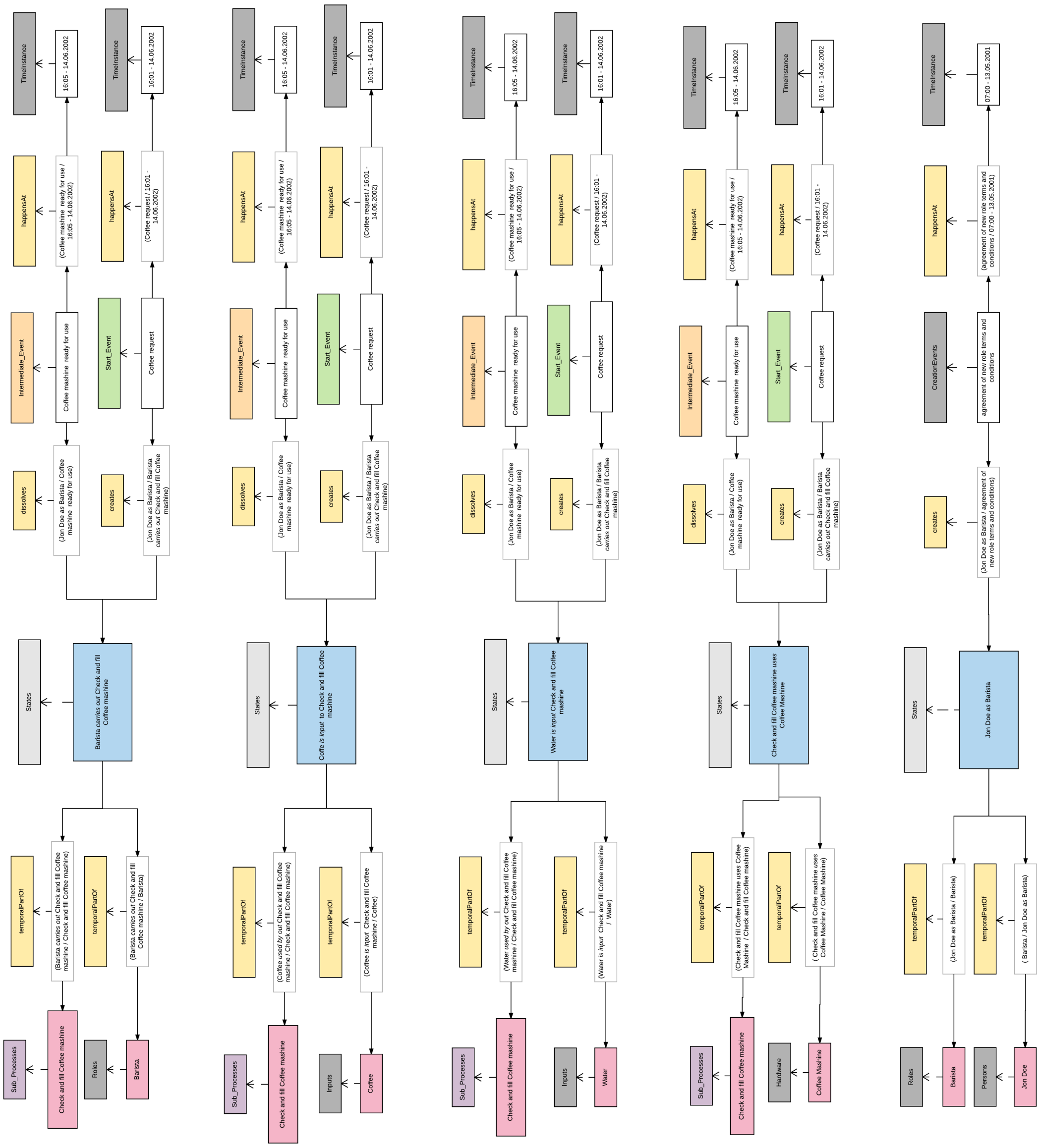

Process_Rescoures
Company_Process_Resources
Tools
Employees
Hardware
Software
InternalStaff
ContractStaff
9-1_PPL_Fertigungsprozess_planen_absichern
Role

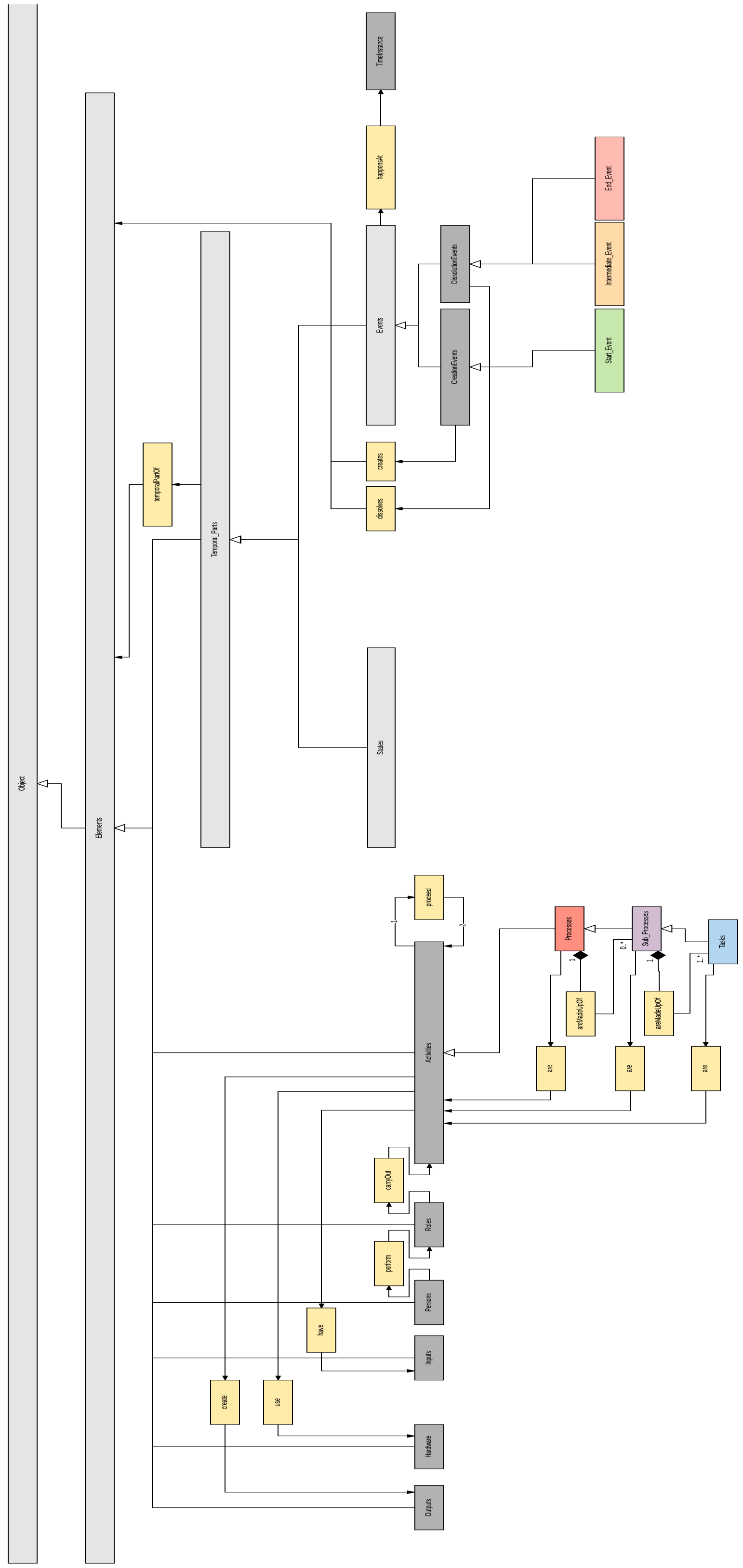

BusinessProcess
Company_Business_Process
T-E/E_Core_Process
Technical_Implementation
9-1_PPL_Fertigungsprozess_planen_absichern

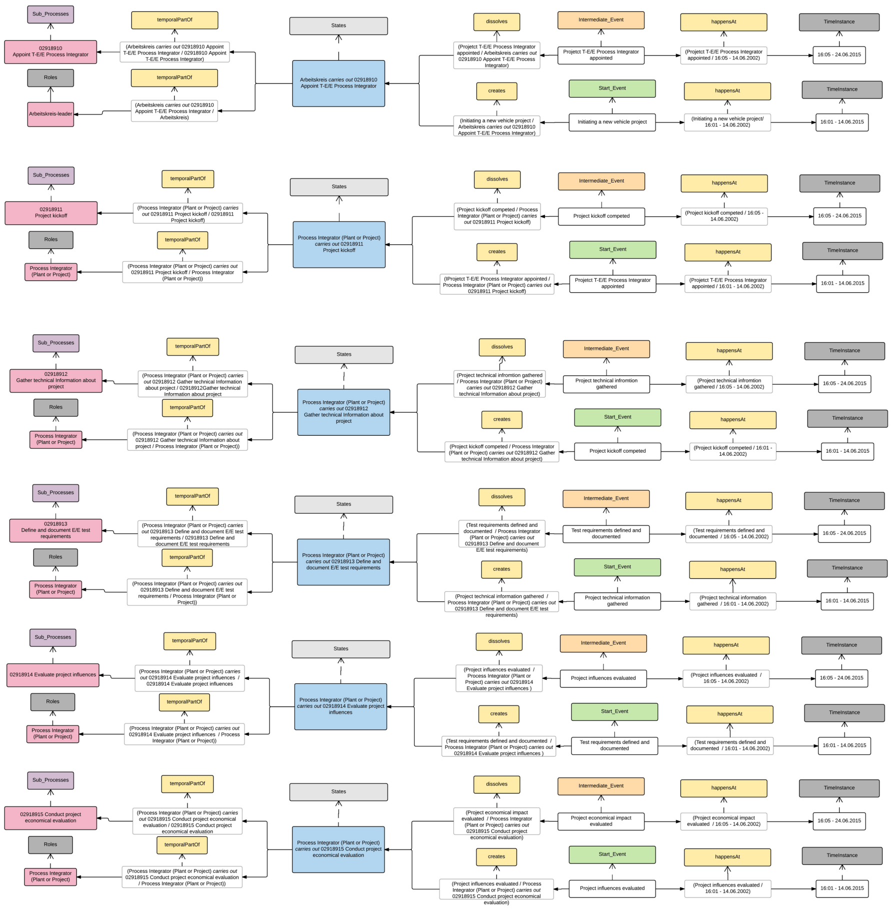

Object
Elements
Temporal_Parts
Events
Process_Events
End_Event
Intermediate_Event
Start_Event
starts
ends
Processes
Sub_Processes
Tasks
areMadeUpOf
areMadeUpOf
are
are
are
States
Activities
carryOut
have
produce
use
Roles
have
Resources
Employees
isA
isMadeUpOf
Persons
Inputs
Outputs
Tools

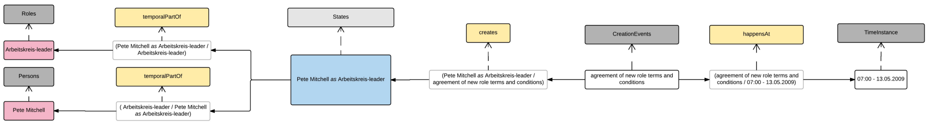

Object
Elements
Temporal_Parts
Events
Process_Events
End_Event
Intermediate_Event
Start_Event
starts
ends
Processes
Sub_Processes
Tasks
areMadeUpOf
areMadeUpOf
are
are
are
States
Activities
carryOut
Job_Roles
carryOut
use
produce
have
Actors
Resources
Tools
Outputs
Inputs

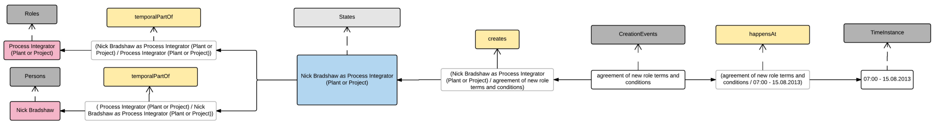


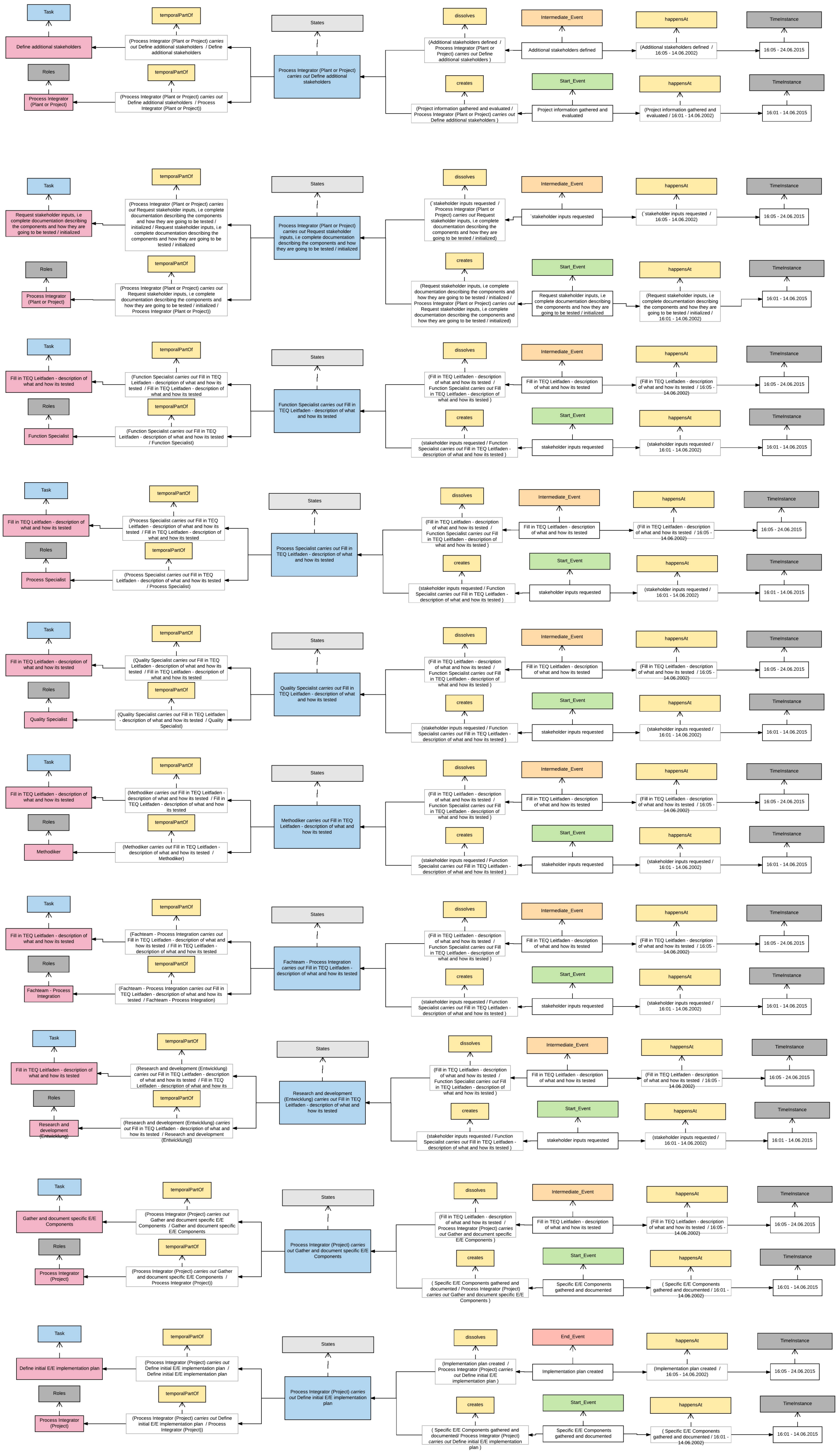


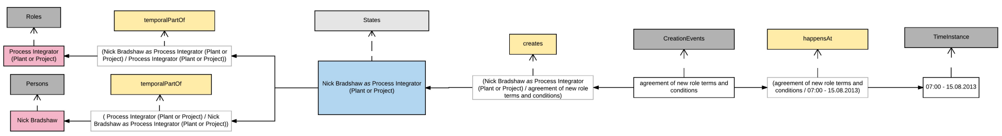

Object
Elements
Temporal_Parts
temporalPartOf
TimeInstance
happensAt
Events
DissolutionEvents
CreationEvents
End_Event
Intermediate_Event
Start_Event
creates
dissolves
States
proceed
Activities
Processes
Sub_Processes
Tasks
areMadeUpOf
areMadeUpOf
are
are
are
carryOut
Roles
perform
Persons
have
Inputs
create
use
Hardware
Outputs

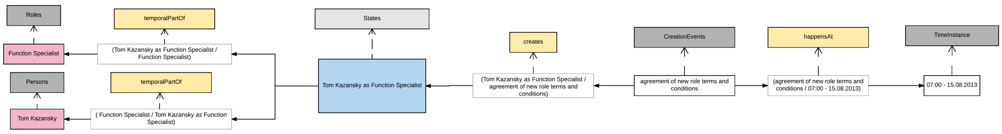


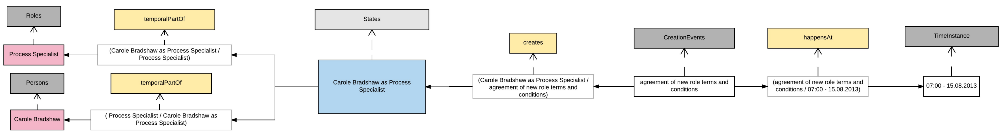

Roles
temporalPartOf
States
creates
CreationEvents
happensAt
TimeInstance
Arbeitskreis-leader
(Pete Mitchell as Arbeitskreis-leader / Arbeitskreis-leader)
Persons
temporalPartOf
Pete Mitchell as Arbeitskreis-leader
(Pete Mitchell as Arbeitskreis-leader / agreement of new role terms and conditions)
agreement of new role terms and conditions
(agreement of new role terms and conditions / 07:00 - 13.05.2009)
07:00 - 13.05.2009
Pete Mitchell
(Arbeitskreis-leader / Pete Mitchell as Arbeitskreis-leader)

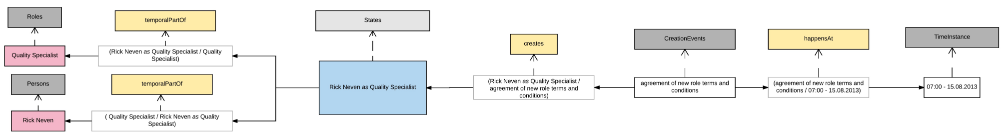

Roles
temporalPartOf
States
creates
CreationEvents
happensAt
TimeInstance
Process Integrator (Plant or Project)
(Nick Bradshaw as Process Integrator (Plant or Project) / Process Integrator (Plant or Project))
Persons
temporalPartOf
Nick Bradshaw as Process Integrator (Plant or Project)
(Nick Bradshaw as Process Integrator (Plant or Project) / agreement of new role terms and conditions)
agreement of new role terms and conditions
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
07:00 - 15.08.2013
Nick Bradshaw
(Process Integrator (Plant or Project) / Nick Bradshaw as Process Integrator (Plant or Project))

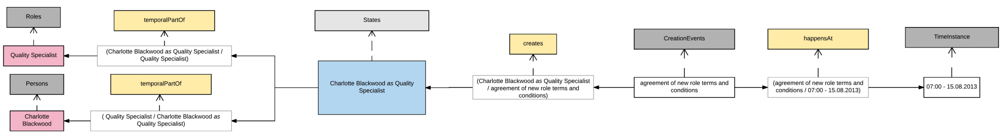


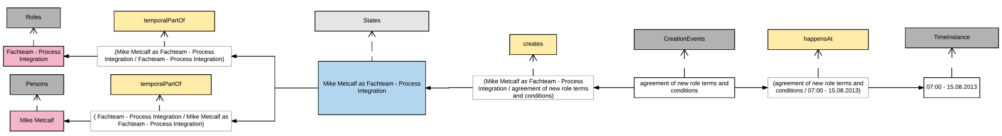

Roles
temporalPartOf
States
Process Integrator (Plant or Project)
(Nick Bradshaw as Process Integrator (Plant or Project) / Process Integrator (Plant or Project))
Persons
temporalPartOf
Nick Bradshaw
(Process Integrator (Plant or Project) / Nick Bradshaw as Process Integrator (Plant or Project))
Nick Bradshaw as Process Integrator (Plant or Project)
creates
(Nick Bradshaw as Process Integrator (Plant or Project) / agreement of new role terms and conditions)
CreationEvents
agreement of new role terms and conditions
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
TimeInstance
07:00 - 15.08.2013

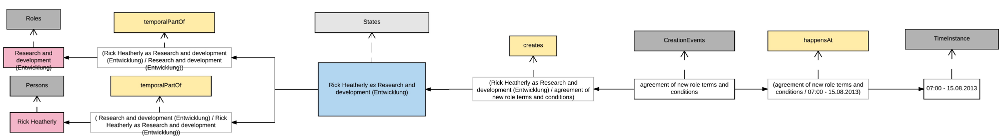

Roles
temporalPartOf
States
Function Specialist
(Tom Kazansky as Function Specialist / Function Specialist)
Persons
temporalPartOf
Tom Kazansky
(Function Specialist / Tom Kazansky as Function Specialist)
Tom Kazansky as Function Specialist
creates
(Tom Kazansky as Function Specialist / agreement of new role terms and conditions)
CreationEvents
agreement of new role terms and conditions
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
TimeInstance
07:00 - 15.08.2013

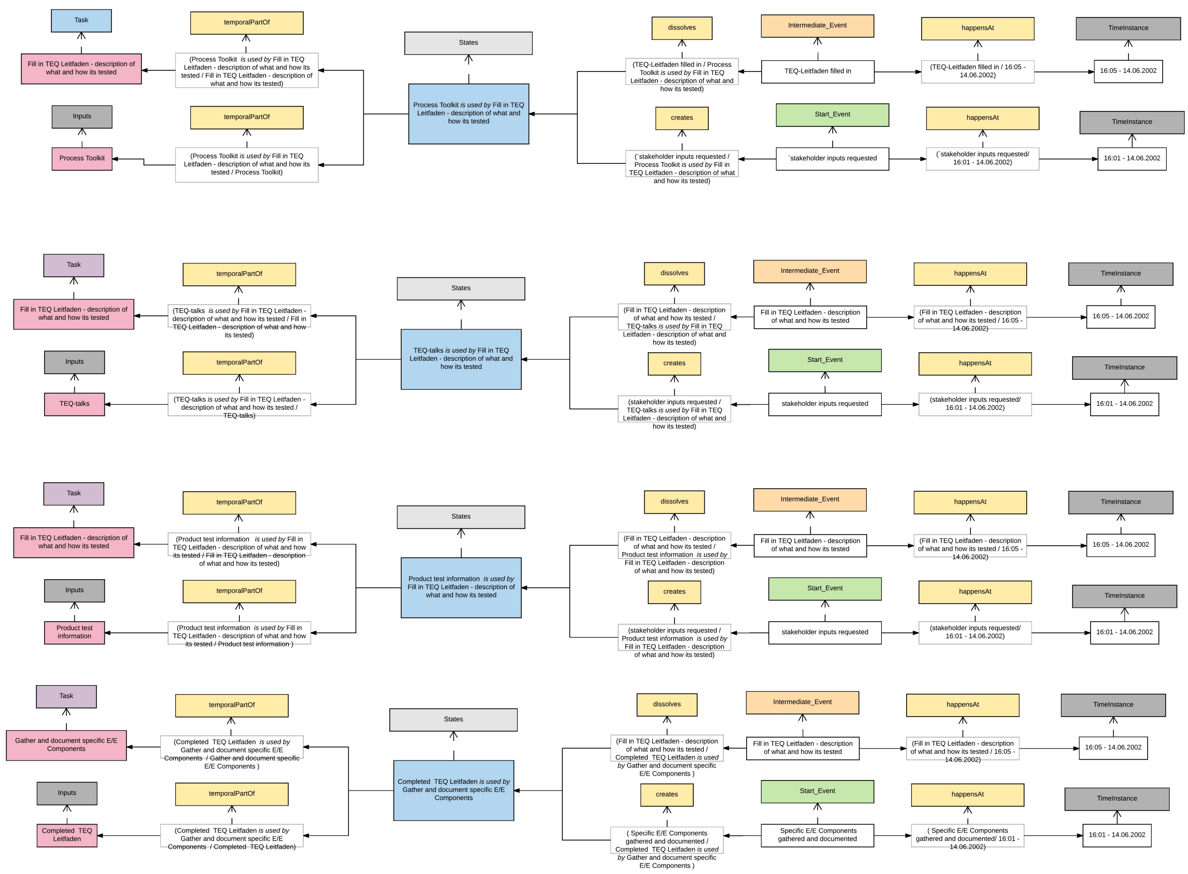

Roles
temporalPartOf
States
Process Specialist
(Carole Bradshaw as Process Specialist / Process Specialist)
Persons
temporalPartOf
Carole Bradshaw
(Process Specialist / Carole Bradshaw as Process Specialist)
Carole Bradshaw as Process Specialist
creates
(Carole Bradshaw as Process Specialist / agreement of new role terms and conditions)
CreationEvents
agreement of new role terms and conditions
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
TimeInstance
07:00 - 15.08.2013

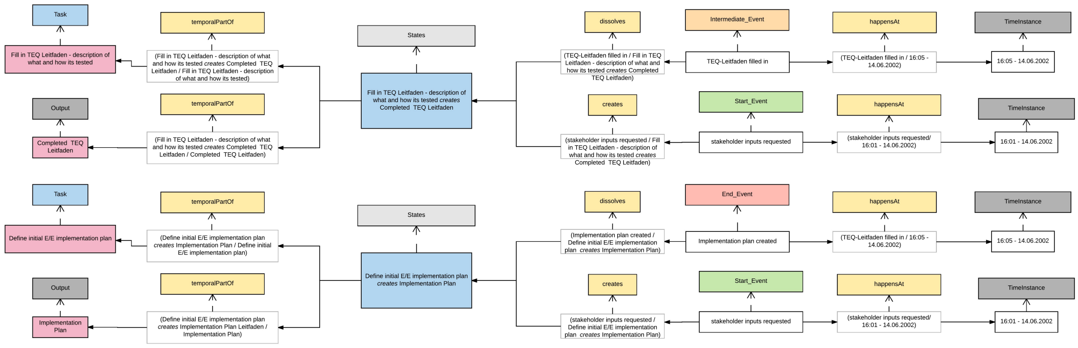

Roles
temporalPartOf
States
Quality Specialist
(Rick Neven as Quality Specialist / Quality Specialist)
Persons
temporalPartOf
Rick Neven
(Quality Specialist / Rick Neven as Quality Specialist)
Rick Neven as Quality Specialist
creates
(Rick Neven as Quality Specialist / agreement of new role terms and conditions)
CreationEvents
agreement of new role terms and conditions
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
TimeInstance
07:00 - 15.08.2013

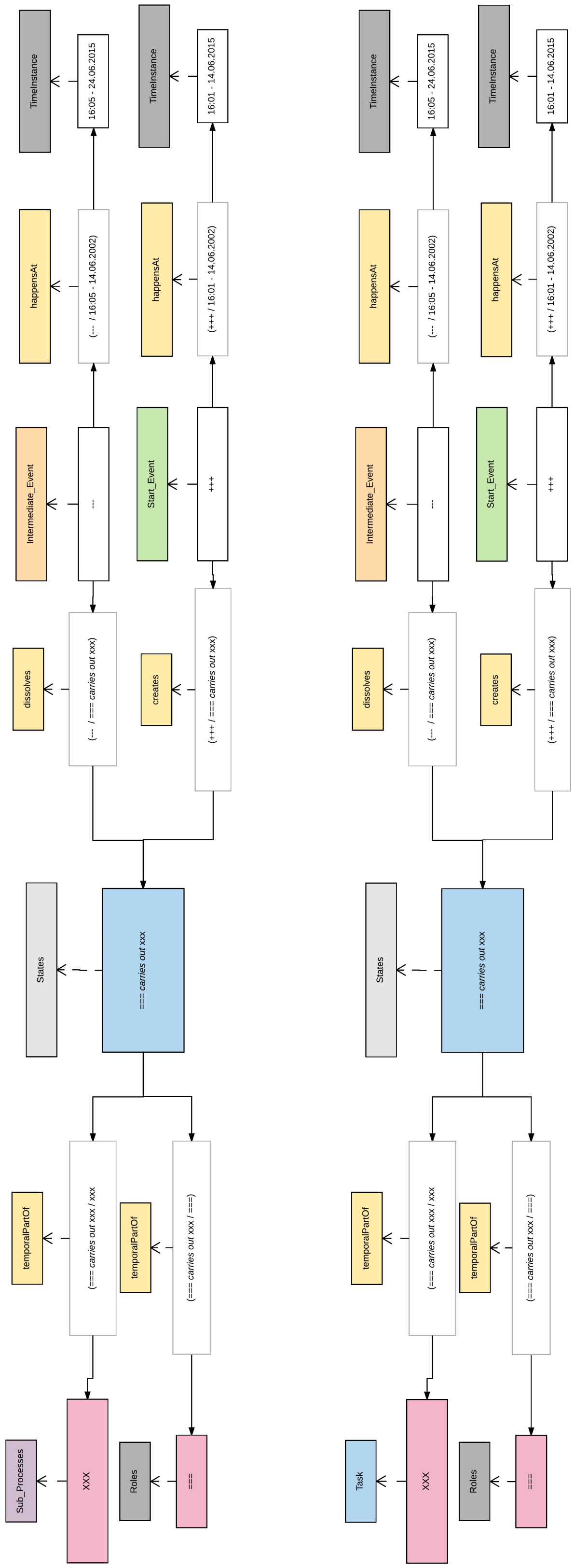

Roles
temporalPartOf
States
Quality Specialist
(Charlotte Blackwood as Quality Specialist / Quality Specialist)
Persons
temporalPartOf
Charlotte Blackwood
(Quality Specialist / Charlotte Blackwood as Quality Specialist)
Charlotte Blackwood as Quality Specialist
creates
(Charlotte Blackwood as Quality Specialist / agreement of new role terms and conditions)
CreationEvents
agreement of new role terms and conditions
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
TimeInstance
07:00 - 15.08.2013


Roles
temporalPartOf
States
Fachteam - Process Integration
(Mike Metcalf as Fachteam - Process Integration / Fachteam - Process Integration)
Persons
temporalPartOf
Mike Metcalf
(Fachteam - Process Integration / Mike Metcalf as Fachteam - Process Integration)
Mike Metcalf as Fachteam - Process Integration
creates
(Mike Metcalf as Fachteam - Process Integration / agreement of new role terms and conditions)
CreationEvents
agreement of new role terms and conditions
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
TimeInstance
07:00 - 15.08.2013


Roles
temporalPartOf
States
Research and development (Entwicklung)
(Rick Heatherly as Research and development (Entwicklung) / Research and development (Entwicklung))
Persons
temporalPartOf
Rick Heatherly
(Research and development (Entwicklung) / Rick Heatherly as Research and development (Entwicklung))
Rick Heatherly as Research and development (Entwicklung)
creates
(Rick Heatherly as Research and development (Entwicklung) / agreement of new role terms and conditions)
CreationEvents
agreement of new role terms and conditions
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
TimeInstance
07:00 - 15.08.2013

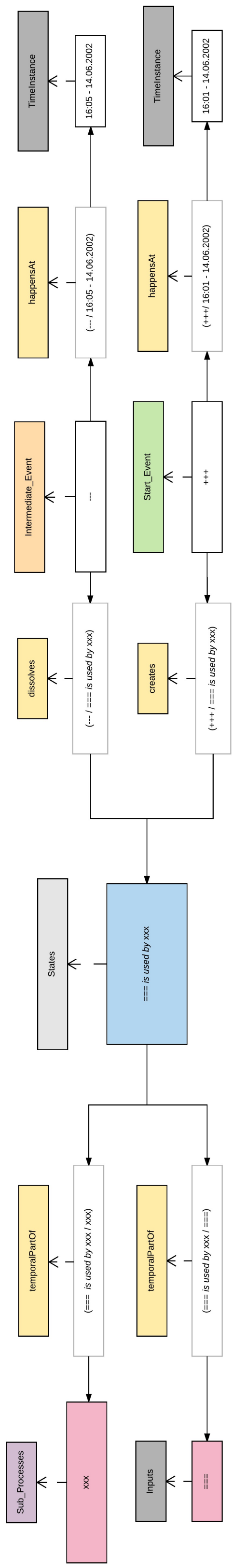

Task
temporalPartOf
States
dissolves
Intermediate_Event
happensAt
TimeInstance
Inputs
creates
Start_Event
Fill in TEQ Leitfaden - description of what and how its tested
Process Toolkit
TEQ-Leitfaden filled in
16:05 - 14.06.2002
16:01 - 14.06.2002
TEQ-talks
Product test information
Gather and document specific E/E Components
Completed TEQ Leitfaden
stakeholder inputs requested
Specific E/E Components gathered and documented


Task
temporalPartOf
States
dissolves
Intermediate_Event
happensAt
TimeInstance
Fill in TEQ Leitfaden - description of what and how its tested
(Fill in TEQ Leitfaden - description of what and how its tested creates Completed TEQ Leitfaden / Fill in TEQ Leitfaden - description of what and how its tested)
(TEQ-Leitfaden filled in / Fill in TEQ Leitfaden - description of what and how its tested creates Completed TEQ Leitfaden)
TEQ-Leitfaden filled in
(TEQ-Leitfaden filled in / 16:05 - 14.06.2002)
16:05 - 14.06.2002
Fill in TEQ Leitfaden - description of what and how its tested creates Completed TEQ Leitfaden
Output
temporalPartOf
creates
Start_Event
happensAt
TimeInstance
Completed TEQ Leitfaden
(Fill in TEQ Leitfaden - description of what and how its tested creates Completed TEQ Leitfaden / Completed TEQ Leitfaden)
(stakeholder inputs requested / Fill in TEQ Leitfaden - description of what and how its tested creates Completed TEQ Leitfaden)
stakeholder inputs requested
(stakeholder inputs requested/ 16:01 - 14.06.2002)
16:01 - 14.06.2002
Task
temporalPartOf
States
dissolves
End_Event
happensAt
TimeInstance
Define initial E/E implementation plan
(Define initial E/E implementation plan creates Implementation Plan / Define initial E/E implementation plan)
(Implementation plan created / Define initial E/E implementation plan creates Implementation Plan)
Implementation plan created
(TEQ-Leitfaden filled in / 16:05 - 14.06.2002)
16:05 - 14.06.2002
Define initial E/E implementation plan creates Implementation Plan
Output
temporalPartOf
creates
Start_Event
happensAt
TimeInstance
Implementation Plan
(Define initial E/E implementation plan creates Implementation Plan Leitfaden / Implementation Plan)
(stakeholder inputs requested / Define initial E/E implementation plan creates Implementation Plan)
stakeholder inputs requested
(stakeholder inputs requested/ 16:01 - 14.06.2002)
16:01 - 14.06.2002

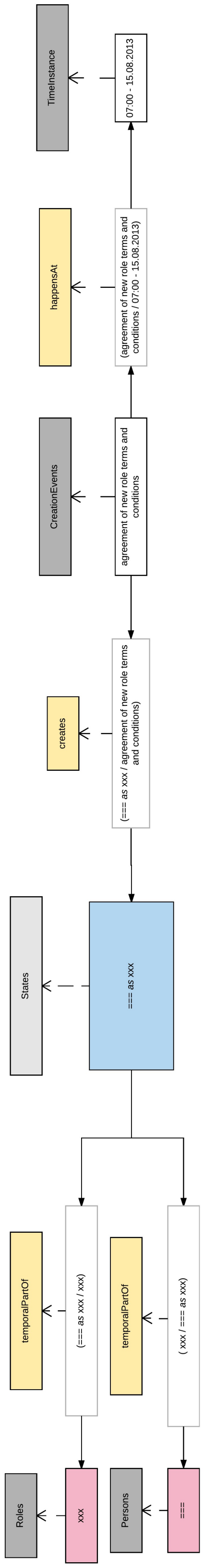


TimeInstance
16:05 - 24.06.2015
TimeInstance
16:01 - 14.06.2015
happensAt
(--- / 16:05 - 14.06.2002)
happensAt
(+++ / 16:01 - 14.06.2002)
Intermediate_Event

Start_Event
+++
dissolves
(--- / === carries out xxx)
creates
(+++ / === carries out xxx)
States
=== carries out xxx
temporalPartOf
(=== carries out xxx / xxx
temporalPartOf
(=== carries out xxx / ===)
Sub_Processes
XXX
Roles
===
Task


TimeInstance
16:05 - 14.06.2002
TimeInstance
16:01 - 14.06.2002
happensAt
(--- / 16:05 - 14.06.2002)
happensAt
(+++/ 16:01 - 14.06.2002)
Intermediate_Event

Start_Event
+++
dissolves
(--- / === is used by xxx)
creates
(+++ / === is used by xxx)
States
=== is used by xxx
temporalPartOf
(=== is used by xxx / xxx)
temporalPartOf
(=== is used by xxx / ===)
Sub_Processes
xxx
Inputs
===


TimeInstance
07:00 - 15.08.2013
happensAt
(agreement of new role terms and conditions / 07:00 - 15.08.2013)
CreationEvents
agreement of new role terms and conditions
creates
(=== as xxx / agreement of new role terms and conditions)
States
=== as xxx
temporalPartOf
(=== as xxx / xxx)
temporalPartOf
(xxx / === as xxx)
Roles
xxx
Persons
===